THE UNIVERSITY
OF ILLNIOIS
LIBRARY
6R5.05
RAL
V.6
EMOTE STORAGE

625.05
RAL
REMOTE STORAGE

Contents of Vol. VI

Railway Electrical Engineer

June 1914 to May 1915

A

A. B. C. Car Lighting Lessons:
  Lesson 29, Adams & Westlake Newbold System.... 27
  Lesson 30, The American Headlight, Model "F"..... 61
  Lesson 31, Type "L" Consolidated Axle Equipment with Ampere Hour Meter Control.................. 91
  Lesson 32, U. S. L. System with Ampere Hour Meter Control 123
  Lesson 33, Brown Boveri (German) System.........181
  Lesson 34, Pintsch-Grob (German) System..........218
  Lesson 35, G. E. Z. (German) Car Lighting System..243
  Lesson 36, Type "F" Safetv Equipment.............266
  Lesson 37, Safety Type "F" Axle Lighting Equipment 290
  Lesson 38, Inspection of "Safety" Equipment........317
  Lesson 39, Some Peculiar Things About Battery Grounds 345
  Lesson 40, Regulator Adjustment 370
Adams & Westlake Newbold System.................... 27
Adjustable Shunt for C-2 U. S. Panel....................322
Aerial Telephone Line..100
Alternating Current Machinery, Three Phase Windings for 337
Alternating Currents, Principle of, By Willard Doud.... ....287, 339, 366
Alternating Current Windings, By J. H. Wickman......315
American Electric Railway Association, Hand Book of... 56
American Headlight, Model "D"........................ 61
Ammeter Jack from an Old Ferrule Fuse...............347
Ampere Hour Meter as Standard Part of Axle Equipment, Consolidated Co. Adopts.................... 29
Ampere Hour Meter Control...........................312
Ampere Hour Meter Control, U. S. L. System with.....123
Ampere Hour Meter Control, with Consolidated Type "L" Axle 91
Ampere Hour Meter for Pullman Co.....................323
Ampere Hour Meter in Car Lighting Service............ 16
Ampere Hour Meter in Car Lighting Service, Graphic...258
Ampere Hour Meter, Measuring Amperes with..........361
Anderson Plugs and Receptacles, New.................. 36
Annual Convention Arrangements....................... 69
Annual Convention of the A. R. E. E....................101
Anticipated Economies in the St. Paul Electrification..... 1
Arc Lamps Converted Into Nitrogen Lamp Containers..375
Arc Welding, Electric..131
A. R. E. E. Coach Lighting Tests...................... 1
A. R. E. E. Semi-Annual Convention 14
Armatures, New Method of Rewinding..................129
A. R. M. M. Committee on Locomotive Headlights...... 44
Armored Cables for Car Lighting........................298
Atlantic City Convention......................................353
Automatic Battery Charging Current Regulator..........262
Automatic Block Signal System for Shop Traveling Cranes, By E. Wanamaker..........................328
Automatic Motor Starters, Direct Current..............351
Automatic Rheostat for Battery Charging...............223
Automatic Switch on U. S. L. Machine, Test for........247
Auxiliary Trucks for 2400 Volt Locomotives............ 75
Axle Belting, Committee on............................ 14
Axle Car Lighting vs. Headend Systems................225
Axle Equipment, Consolidated Type "L" with Ampere
Axle Equipment, Report of Committee on...........14, 134
  Hour Meter Control 91
Axle Generator Ball Bearings, Yearly Greasing..........372
Axle Generator Cable..298
Axle Generator Terminal Box................................323
Axle Lighting Equipment, Safety Type "F"..............290
Axle Lighting System, Head End..........................301

B

Ball Bearings, Communication on..........................186
Ball Bearings, for Car Fans..................................101
Ball Bearing Operation, Interesting Results of.........187
Ball Bearings, Strength of....................................187
Barge, Coal, Loading Plant....................................362
  Charging 171
Batteries for Headlight Service, Storage................. 52
Batteries, Lead, How Made...................................312
Batteries, Report of Committee on Yard Facilities for
Battery Charging Current Regulator, Automatic.........262
Battery Circuit, Testing for Open......................... 66
Battery Connectors, No More Loose.......................224
Battery, Edison Storage, By H. H. Smith................ 79
Battery, Gas, New Type, By Karl Siegl...................111
Battery Handling Crane...321
Battery House for Soo Lines, New........................ 12
Battery House, New Pullman.................................102
Battery Plate Press 95
Battery Questions, Edison......................82, 342, 369
Battery Questions, Lead 89, 121, 184, 220, 240, 282, 263, 284, 312
Battery Tank, New Stoneware...............................248
Battery Tanks Pit More Than Others, Why Certain..... 96
Battery Trays, Easy Method of Removing................271
Battery Tray, New...295
Battery, Willard "No Wash"...................................188
Bauer, W. F..190, 272
Belt Fastener, Bristol.. 52
Belt Repairs 223
Belting, Axle, Report of Committee on.................. 14
Belting Specifications, Report of Committee on.......... 40
Bender, C. W., Appointed General Manager Nela Specialties Division 375
Better Bearings for Car Fans.................................101
Big Installation of Dossert Connectors................... 36
Bridge, Lift, Operated by Remote Control...............302
Bristol Belt Fastener.. 52
Broken Terminal Block...322
Brown Boveri (German) System, A. B. C. Car Ltg. Lesson No. 33 181
Brushes, Home Made.. 66
Buckled Elements, Removing from Hard Rubber Jars...130
Butte, Anaconda & Pacific Ry., Electric Operation of the.233
B. & O. R. R. Abandon Headend Lighting of Trains....238

C

Cable, Axle Generator..298
Cable Connectors, Lead Terminals Cast Directly on.....271
Cables for Car Lighting, Armored..........................298
Cable, Steel Tape Armored.................................... 68
Car, Gas-Electric 232
Car Lighting, Emergency......................................296
Car Lighting Generator Lubrication........................353
Car Lighting Generators, Under Frame Suspension of....327
Car Lighting Man's Job in the Winter Time.............297
Car Lighting Patent Litigation..............................324
Car Lighting Problems, a Practical Study of, By W. C. Gove and L. C. Porter.................................354
Car Lighting Service, Ampere Hour Meter.............. 16
Car Lighting System, G. E. Z. (German); A. B. C. Lesson No. 35 243
Car Wiring, Committee on....................................200
Carriage Lighting in India....................................261
Chinese Chief Electrician, Visits U. S....................297
Chucks, D. & W. Magnetic.................................... 73
Coach, A. R. E. E. Lighting Tests........................ 1
Coal Barge Loading Plant, By H. S. Shimizu...........362
Classification Yard Lighting of the P. & L. E. R. R. at Pittsburgh 216
Combination Hammer and Tension Rod Nut.............187
Committee on Axle Lighting Equipment.........14, 199, 134
Committee on Belting 14
Committee on Car Wiring.....................................200
Committee on Data and Information..............139, 191, 38
Committee on Electric Headlights.....................144, 192
Committee on Electric Traction....................38, 175, 199
Committee on Engineering Manual and Loose Leaf Binders 139

Committee on Head End Equipment...199, 145
Committee on Illumination...201, 149, 40
Committee on Industrial Trucks...198, 151
Committee on Lamps... 15
Committee on Line Construction...325
Committee on Loose Leaf Binders... 41
Committee on Outside Construction and Yard Lighting...153, 201, 41
Committee on Reciprocal Relations...160
Committee on Shop Practice...202, 42
Committee on Specification for Belting... 40
Committee on Standards...152, 192, 42
Committee on Standard Rules for Car Wiring...161
Committee on Standardization of Train Lighting Lamps.171
Committee on Wire and Cable Specifications....199, 163, 43
Committee on Wire Crossing Specifications...160
Committee on Wire Crossings for Potentials Above 100 Volts...191
Committee on Yard Facilities for Charging Batteries...201, 43, 16, 171
Communication on Ball Bearings...186
Commutation...312
Commutator Construction, New...249
Commutator, Short Circuited...128
Compressing Air, Cost of Power for, By H. R. Bucks... 10
Convention, Manufacturers' Exhibits...211
Convention, Seventh Annual...133, 134, 191
Converting Arc Lamps Into Nitrogen Lamp Containers..375
Conduit Wiring for Railway Cars...110
Consolidated Company Adopts Ampere Hour Meter as Standard Part of Axle Equipment... 29
Consolidated Type "L" Axle Equipment with Ampere Hour Meter Control... 91
Constant Potential Charging and the E. S. B. System, By J. Lester Woodbridge...310
Construction and Yard Lighting, Report of Committee on.201
Cost of Power for Compressing Air, By H. R. Bucks.... 10
Crane Battery Handling...321
Crane Electro Magnets, Turbo Generators to Energize...113
Crane Motors, Standardization of...247
Crane, 100 Ton Electrically Operated Tunnel... 5
Cranes, Automatic Block Signal System, By E. Wanamaker...328
Current Adjustment on Type "C" U. S. L. Panel...323
Curve Readings... 20
C. M. & St. P. Ry. Electrification...256
C. M. & St. P. Ry. Electrification of Mountain Division.225

D

Data and Information, Committee on...139, 191
Development of the Gas Filled Mazda, C. L. Dows... 73
Dictionary, English-German Technical...300
Direct Current Automatic Motor Starters, Shop Motor Section...351
Direct Current Machines, Shop Motor Section...265
Dossert Connectors, Big Installation of... 36
D. & W. Magnetic Chucks...273
D. & W. Oil Fuse Cutouts... 34

E

Easy Method of Removing Battery Trays...271
Easy Rule for Estimating Electrical Input to Motors.... 95
Edison Exhibit at Panama Exhibition...351
Edison Storage Battery, H. H. Smith... 79
Edison Storage Battery Questions...82, 342, 369
Edison Works Fire...273
Election of Officers, A. R. E. E...205
Electric Arc Welding...131
Electric Arc Welding in Steam Railway Shops, Geo. W. Cravens... 76
Electric Headlights, Report of Committee on...144
Electric Lighting, a Factor in Civilization...236
Electric Locomotive in Switching Service... 70
Electric Operation of the B. A. & P. Ry...253
Electric Soldering Tool, Tinning Block for...247
Electric Towing System for Panama Canal Locks...276
Electric Traction, Last Year's Progress in...252
Electric Traction, Progress in...251
Electric Traction, Report of Committee on...38, 175
Electrical Club, Pacific Coast...369
Electrically Operated Tunnel Crane... 5
Electrification, Anticipated Economies in St. Paul... 1
Electrification, Equipment for Pennsylvania R. R...324
Electrification, Notes on Steam R. R...106
Electrification Pennsylvania R. R., Suburban, at Philadelphia... 7
Electrification, Mountain Division C. M. & St. P. R. R....225, 226
Electrification, N. & W. R. R., and Penn. R. R...335
Electrification, Operating Results of...332
Electrification, Prussian Railways Proposed...309
Electrification, Purchase of Power for New Haven...256
Electrification, Results of the New Haven...279
Electrolytic Iron, Magnetic Properties... 48
E. S. B. Axle Lighting System... 67
E. S. B. System, Constant Potential Charging...310
Emergency Car Lighting...296
Emergency Welding...179
Engineering Manual, Report of Committee on...148
Equipment for P. R. R. Electrification...324
Exciter Lamp Trouble...296
Exhibits at A. R. E. E. Annual Convention...211
Exhibits at Atlantic City Convention... 46
Exhibits at Panama Exposition...351

F

Fans, for Railroad Coaches...114
Field Fuse Trouble... 32
Fire Proofing Wood...223
Fundamental Principles of the E. S. B. Axle Lighting System... 67
Fuse Cutouts, "D. & W." Oil... 34
Fuse, Field Trouble... 32

G

Gas-Electric Car...232
Gas Electric Motor Cars for the St. L. S. W. R. R....131
Gas Filled Mazda... 69
Gas Filled Mazda, Development of the... 73
Gas Filled Mazdas for Lighting Railroad Offices...272
General Lead Batteries Co...300
Generator Belts, Preventing Loss of...347
Generator Lubrication for Car Lighting...353
Generator, Short Circuited Test of...111
Generator Suspension, New "Safety"... 35
Generator Terminal Box...323
G. E. Z. (German) Car Lighting System...243
Graphic Ampere Hour Meter in Car Lighting Service...258
Grounded Field Coil in Moskowitz Generator...187
Ground, Locating on Storage Battery... 66
Grounds, Some Peculiar Things About Battery...345
Grounds, Test for...223

H

Hand Book for Electrical Engineers...325
Hand Book of American Electric Railway Association... 56
Hanger, Single Rope Automatic Cutout... 68
Head End Axle Lighting System...301
Head End Equipment, Report of Committee on..40, 145, 199
Head End Lighting of Trains Abandoned by B. & O. R. R...238
Head End vs. Axle Car Lighting System...225
Headlights, Electric, Report of Committee on...192
Headlights, Locomotive, By J. R. Minick...205
Home Made Brushes... 66
Home Made Plug for Extension Cord...322
How Lead Batteries Are Made...312
Humphrey, E. A...272

I

I. E. S. Convention...98, 114
Illumination, Report of Committee on...40, 149, 201
Importance of Good Lighting in Railroad Service...275
Incandescent Units, Lighting of Railroad Yards, with Large...228
Inclinator, Union Carboy...249
Induction Motor Regulator, New...132
Industrial Trucks, Report of Committee on...151
Influence of Battery Charging Current on Lamp Voltage, U. S. L. Pullman System...245
Inspection of "Safety" Equipment...317
Insulators, Rubber Jar, Breakage Due to... 32
Insulator Testing...249
Interesting Results of Ball Bearing Operation...187
International Engineering Congress...325
Interpole Direct Current Machines...265
Intra-Mural Railway at Panama Exposition...217

K

Kerosene Torch, New...130
Keystone Railroad Pulley, New...130

L

Lamp Committee Report........................15, 43, 171
Lamp Voltages, Influence of Battery Charge Current....245
Lamps, New Fixtures and Fittings................188, 375
Lamps, Small Mazdas with Concentrated Filaments.....351
Lead Storage Battery, H. M. Beck...................... 53
Lead Storage Battery Questions.................................89, 121, 184, 220, 240, 263, 282, 312, 342
Lead Terminal for Connectors..........................271
Leaky Tanks, Test for.................................130
Life of a Storage Battery..............................373
Lift Bridge Operated by Remote Control..............302
Lighter for Hydrogen Burners, Sparkless............... 95
Lighting, A Practical Study of, By W. C. Gove and L. C. Porter 354
Lighting in Railway Cars, Semi-Indirect................ 34
Lighting Carriages in India............................261
Lighting Classification Yards, P. & L. E. R. R..........216
Lighting of Offices with Gas Filled Mazdas..............272
Lighting of Railroad Yards with Type "C" Mazdas, L. C. Doane 228
Lighting of Yards 189
Lighting, Electric, a Factor in Civilization.............236
Lighting Unit, Mast Arm Mounting.....................347
Lighting, Importance of in R. R. Service................275
Line Construction, Joint Committee on..................325
Liners in Battery, Quick Method of Placing............272
Locating Grounds on a Storage Battery................. 66
Locating Polarity of Train Lines....................... 32
Lock Nut, Easy Way of Removing from Armature......271
Locomotive, Electric Ore Dock.........................112
Locomotive, Electric, in Switching Service............. 70
Locomotive Headlight Committee...................... 44
Locomotives, Auxiliary Trucks for, 2400 Volt........... 75
Locomotives, Three Phase Italian......................307
Locomotives, Test of Norfolk & Western Split Phase...324
Loose Leaf Binders, Committee on..................... 41
Lubrication of Car Lighting Generators.................353
Lunn, Ernest, Appointed Ch. Elec. Pullman Co.......... 99

M

Magnetic Properties of Electrolytic Iron............... 48
Manufacturers' Exhibits at A. R. E. E. Convention......211
Manual of Electrical Testing........................... 29
Mast Arm for Mounting Lighting Unit..................351
Master Mechanics and Electrification.................. 37
Maxolite Fitting, Type "R"............................130
Mazdas, Gas Filled................................69, 73
M. C. B. Committee on Train Lighting................. 43
Meloy, H. C...190
Measuring Amperes with an Ampere Hour Meter.......361
Measuring 600 Volts on a 100 Volt Meter............... 96
Mica Under-Cutting with Armature in Place.........32, 372
Million Volt Testing Transformer......................261
Motor Cars for S. L. & S. W. R. R.....................131
Motor, Two Speed, Shop Motor Section.................239
Motors, Easy Rule for Estimating Input................ 95
Mudge & Co. Ventilator................................132

N

National Joint Committee on Line Construction..........325
New Method of Rewinding Armatures..................129
New Principle in Railway Car Ventilation.............. 99
Nitrolite Jingle Contest................................224
Norfolk & Western Electrification......................335
Norfolk & Western Locomotives, Test of................324
No More Loose Battery Connectors.....................224
Notes on Steam Railway Electrification.................106

O

Ohm's Law, Lesson on.................................. 24
Open End Truck..189
Operating Results of Steam Railroad Electrification.....332
Ore Dock Electric Locomotive..........................112
Outside Construction and Yard Lighting, Report of Committee on 41, 153
Overhead Line Crossings, Safety at.....................299
Overhead Wiring Crossings, Report of Committee on.... 41
Overload Relays 113

P

Pachaly, R. W..374
Pacific Coast Railway Electrical Club...................369
Panama Exposition 99, 217, 281, 311
Peculiar Regulator Trouble............................347
Pennsylvania R. R. School of Electricity...............219
Pennsylvania R. R. Storage Battery Car.................255
Pennsylvania R. R. Suburban Electrification............. 7
Pintsch-Grob (German) System.........................218
Polarity of Train Line, Testing......................... 32
Pomeroy, L. R.. 67
Portable Substation 233
Plugs and Receptacles, Anderson....................... 36
Poles, Test for North and South....................... 96
Plug for Extension Cord................................322
Plates, Sulphated 311
Practical Study of Car Lighting Problems, Gove and Porter 354
Practical Stunts Are Indexed Under Subject Titles...... ..
Principles of Alternating Currents, Willard Doud..287, 339, 366
Program of A. R. E. E. Convention.....................109
Progress in Electric Traction...........................251
Prosperity in the Five Per Cent in Freight Rates........251
Pullman Battery House, New...........................102
Pullman Co. Take Over P. R. R. Car Lighting..........250
Purchase of Power for New Haven Electrification.......256

Q

Question Box (Refer to Subject Heading).
Quick Method of Placing Liners in Battery..............272
Quinn, C. H., Appointed Electric Engineer of N. & W. Ry. 98

R

Railroad Coach Fans...................................114
Railroad Electricians' Club.
    Constant Potential Charging and the E. S. B. System.310
    Edison Storage Battery Question...................369
    Electric Storage Battery Question........89, 263, 282, 342
    Lead Storage Battery Question..........121, 184, 220, 240
    Ohm's Law 24, 59
Railway Electrical Club, Pacific Coast..................369
Reciprocal Relations, Report of Committee on...........160
Regulator, Automatic Battery Charging Current..........262
Regulator, Induction Motor.............................132
Regulator Trouble 347
Removing Buckled Elements from Hard Rubber Jars...130
Rheostat for Battery Charging, Automatic..............223
Rubber Jar Breakage Due to Insulators................ 32
Rule for Estimating Electrical Input to Motor.......... 95
Rules for Car Wiring, Report of Committee on.........161

S

Safety at Overhead Line Crossings.....................299
Safety Company's "Under Frame" Equipment..........348
Safety Equipment, Inspection..........................317
Safety Equipment, Type "F"...........................266
Safety Type "F" Axle Lighting Equipment..............290
School of Electricity.
    No. 13. Curve Reading 20
    No. 14. Mathematics, Whole Numbers............. 57
    No. 15. Mathematics, Continued 86
    No. 16. Fractions 115
Semi-Annual Convention of A. R. E. E.................. 38
Semi-Indirect Lighting in Railway Cars................ 34
Semi-Outdoor Portable Substation......................233
Seventh Annual Convention...................133, 134, 191
Shop Motor Section. By J. H. Wickman.
    Alternating Current Windings.......................315
    Interpole Direct Current Machines..................265
    Simplified Three Phase Windings....................363
    Synchronizing A. C. Machinery......................284
    Three Phase Windings for Alternating Current Machinery 337
    Two Speed Motor...................................239
Shop Practice, Report of Committee on.............42, 202
Short Circuited Commutator............................148
Short Circuited Test of a Large Generator..............111
Shunt, Adjustable for C-2 U. S. Panel..................322
Signal Lighting Transformers..........................274
Signal System for Shop Traveling Cranes, By E. Wanamaker 328
Simplified Three Phase Windings, By J. H. Wickman...363
Single Rope of Automatic Cutout Lamp Hangers....... 68
Some Peculiar Things About Battery Ground...........345
Some Results of the New Haven Electrification.........279
Sparkless Lighter for Hydrogen Burners............... 95
Special Lamp Committee...............................343
Specifications for Overhead Wiring Crossings...........341
Standardization of Crane Motors........................247

Standardization of Motor Sizes for Traveling Cranes....133
Standards, Report of Committee on..............42, 152,192
Station Lighting, New Pendant Fixture for.............273
Steam Railroad Electrification, Operating Results of....332
Steel Tape Armored Cables............................ 68
Storage Batteries for Headlight Service................. 52
Storage Battery, Locating Grounds on.................. 56
Storage Battery Questions, Edison..............82, 342, 369
Storage Battery Questions, Lead........................ ....89, 121, 184, 220, 240, 263, 282, 312, 342
Storage Battery Tractor...............................350
Strength of Ball Bearings.............................187
Substation, Semi-Outdoor Portable.....................233
Sulphated Plates 311
Summer Vacation Notes................................ 97
Suspension of Car Lighting Generators, Underframed...327
Synchronizing, A. C. Machinery, By J. H. Wickman.....284

T

Tail Rod Guide for Bliss Regulator....................322
Team Work 33
Telephone Train Dispatching.......................112-114
Telephone and Telegraph, Wireless, as an Adjunct in the Operation of a Railroad...........................194
Tension Rod Clamp Stunt.............................. 66
Terry Turbines for Italian Navy....................... 98
Test for Automatic Switch on U. S. L. Machines.......247
Test for Leaky Tanks..................................130
Test of Norfolk & Western Single Phase Locomotives...324
Test for Grounds 223
Test for North and South Pole Electro Magnets........ 96
Test, Short Circuited, of a Large Generator..............111
Testing for Open Battery Circuit...................... 66
Testing Insulators 249
Tests of Tractive Resistance.......................... 48
Tests of Storage Battery Car on Penn. R. R............255
Three Phase Italian Passenger Locomotives............307
Three Phase Windings for Alternating Current Machinery, By J. H. Wickman............................337
Three Phase Windings Simplified, By J. H. Wickman...363
Tinning Block for Electric Soldering Tool..............247
Torch, Kerosene 130
Towing System, Electric, for Panama Canal Locks......276
Track Scale and Yard Lighting, By H. Kirschberg and A. C. Cotton 49
Traction, Electric, Report of Committee on............175
Train Dispatching Telephone...........................114
Train Lighting, Report of M. C. B. Committee on....... 43
Transcontinental Voice Highway........................323
Transformer, Million Volt Testing......................261
Transformer, Signaling Lighting........................274
Trucks, Industrial, Report of Committee on.............198
Trucks, Open End......................................189

Tunnel Crane, 100 Ton, Electrically Operated........... 5
Turbo Generator for Energizing Lifting Magnet on Crane 113
Two Speed Motor, By J. H. Wickman.....................239
Type "F" Safety Equipment, A. B. C. Lesson No. 36.....266

U

Undercutting Mica 32
Undercutting Mica with Armature in Place..............372
Under Frame Equipment, Safety Company................348
Under Frame Suspension of Car Lighting Generators....327
Union Carboy Inclinator...............................249
U. S. L. Management and Staff Retained................ 98
U. S. L. System with Ampere Hour Meter Control.....123

V

Ventilation in Railway Cars, New Principle............. 99
Ventilator, Made by Mudge & Co........................132

W

Wanamaker, E. 297
Welding, Electric 131
Welding, Electric Arc, in Steam Railway Shops, By George W. Cravens................................. 76
Welding, Emergency 129
Westinghouse Exhibit at Panama Exposition............281
Why Certain Battery Tanks Pit More Than Others..... 96
Why Don't More Roads Electrify?.......................275
Willard "No Wash" Battery.............................188
Willard Storage Battery Co., New Plant................274
Willard Chicago Office Notes..........................224
Windings Simplified, Three Phase, By J. H. Wickman....363
Wire Crossing Specifications, Report of Committee on...160
Wire Crossings for Potentials Above 100 Volts..........191
Wire Specifications, Report of Committee on............163
Wireless Telegraphy in Railroad Service, By John L. Hogan, Jr. 2
Wireless Telephone and Telegraph as an Adjunct in the Operation of a Railroad, By Frederick Millener.....194
Wireless Telephone 197
Wiring for Railway Cars, Conduit......................110
Wire and Cable Specifications, Report of Committee on 16, 43 199
Wrench Sockets, Use for Wornout.......................247

Y

Yard Facilities for Charging Batteries, Report of Committee on 43, 201
Yard Lighting 37, 189
Yard Lighting and Outside Construction, Report of Committee on 41, 201
Yearly Greasing for Axle Generator Ball Bearings......372

RAL
V. 6

RAILWAY ELECTRICAL ENGINEER

Official Journal
of the Association of Railway Electrical Engineers.

PUBLISHED MONTHLY BY
WRAY PUBLISHING CO.
EDWARD WRAY,
President.
800 ADVERTISING BLDG.—123 W. MADISON ST.
CHICAGO.
Telephone, Randolph 7414.

Entered as second-class matter, August 6, 1909, at the Post Office at Chicago, Ill , under the Act of March 3, 1879.

TERMS OF SUBSCRIPTION
United States, Canada and Mexico . . . Per Year, $1.00
Foreign ....Per Year, $1.50

OUR OBJECT.

The object of this publication is to provide a medium for the free interchange of ideas and experience among those identified with the operation of electrical apparatus as applied to railway practice.

In this mutual exchange of ideas among the men prominent in the field there will result a better understanding and solution of the problems before us and a wonderful inspiration for all to greater achievements.

CONTENTS

Page

Editorial:

A. R. E. E. Coach Lighting Tests.................... 1
Anticipated Economies in St. Paul Electrification.... 1
Wireless Telegraphy in Railroad Service—John L. Hogan, Jr. 2
110-Ton Electrically Operated Tunnel Crane............ 5
Penn. R. R. Suburban Electrification at Philadelphia..... 7
Cost of Power for Compressing Air—H. R. Bucks, Ch. Elec., Oregon Short Line........................ 10
New Battery House for Soo Lines—J. R. Smith, Ch. Elec. M., St. P. & S. S. M............................ 12

Semi-Annual Convention, A. R. E. E.:

Report of Committee on Axle Equipment 14
Report of Committee on Axle Belting 15
Report of Special Committee on Lamps............ 15
Report of Committee on Wire and Cable Specifications 16
The Ampere Hour Meter in Car Lighting Service—By Edward Wray 16

Penn. R. R. "School of Electricity":

Lesson No. 13—Curve Reading..................... 20

Railroad Electricians' Club:

Review Lesson in Ohms Law......................... 24

A. B. C. Car Lighting Course:

Lesson No. 29—The Newbold Axle Lighting System 27
Prize Question Box.. 30
Practical Stunts 32
Team Work 33

With the Manufacturers:

Semi-Indirect Lighting in Railway Cars.............. 34
"D. & W." Oil Fuse Cutouts........................... 34
New "Safety" Generator Suspension.................. 35
New Flush Type "Ralco" Receptacle.................. 36
New Anderson Plugs and Receptacles.................. 36

A. R. E. E. Coach Lighting Tests

As mentioned under the Semi-Annual A. R. E. E. Convention section of this issue, the final report of the tests made by the Association of Railway Electrical Engineers, the L. S. & M. S. Ry. and other railway and manufacturing interests last summer, are now available in bound form. These tests are of a most comprehensive nature, including practically every type of illuminating glassware known to the art at the present time, and as they are of an absolutely unbiased and impartial nature, having been conducted jointly by various railways and manufactures interested, under the auspices of this association, these results can be taken with unqualified assurance of accuracy and reliability.

Having all of this elaborate information at our service, however, does not avail us anything unless the results of these tests are actually used by railroad officials in the selection and design of lighting equipment for railway cars.

Let us not simply pigeon-hole this valuable report, or make use of it as a decorative feature on our library shelves—every chief electrician and electrical engineer should first be familiar with the general results of these tests, and second, should make frequent reference to this report using it as a basis of his own work in car illumination matters.

Anticipated Economies in the St. Paul Electrification

The considerations involved in the abolition of the steam locomotive and the introduction of the electric locomotive on the Montana division of the Chicago, Milwaukee & Puget Sound Railroad are of most fundamental and far reaching importance. Unlike all previous elctrifications, with the exception of the Norfolk & Western, now in the process of construction, electrification in this case has been decided upon almost entirely from a standpoint of reduced operating expense. Although, without doubt, the electric locomotives will handle the traffic much faster and more reliably than do the steam locomotives, the actual economies in operation anticipated have been the deciding factor. The company's engineers estimate that electrification will save at least 25 per cent in the operating costs.

The substitution of electricity, purchased from hydro-electric plants nearby, for steam as motive power will at once release a great number of coal cars which then may be used in revenue producing service. Coal storage yards will be eliminated and water tanks abolished. Engine failures, due to bad water and poor coal, will be eliminated and, as it has been well demonstrated that electric locomotives are more reliable than steam locomotives at their best, there will be a great reduction in the train delays with the incident overtime expense.

The new locomotives will be operated at 3,000 volts direct current or possibly higher and current will be collected from a double trolley wire by two pantographs on each locomotive. These locomotives, with 200 tons each on the drivers, will be operated in pairs and one of these 400-ton double locomotives will be capable of hauling a trailing load of 2,500 tons on a 1 per cent grade, at a speed of 15 to 20 miles per hour. Since the present maximum speed with the steam locomotives in use is 1,650 tons at a speed of 8 to 10 miles per hour, it is anticipated that it will be possible to extend the freight divisions from the present length of 100 miles to a maximum of possibly 200 miles. In addition, it is expected that 60 electric locomotives will easily handle the normal traffic now requiring 82 steam locomotives.

The operating results of this electrification, made by a railroad entirely upon its own initiative and without the coercion of any legislative body, but purely from considerations of economy in operation and increased traffic facilities, will be followed with a great deal of interest by all railroad officials.

319437

Wireless Telegraphy in Railroad Service

John L. Hogan, Jr.

Radio service established on the D., L. & W. R. R. October, 1913, over section of 62 miles of line. Scranton and Binghamton, N. Y., stations are each equipped with modern wireless station. Important trains are equipped with antennae mounted on insulators at each corner of car and closet of coach is fitted up with sending and receiving apparatus. Car equipment consists of one k. w. 500-cycle motor generator set with wireless coils and inductances. Current for operation is taken from the car lighting system. Train equipment can send over 30 miles and receive signals from stations 50 miles distant. Radius of action of main stations is 500 miles.

It is proposed to use wireless for direct communication between Hoboken and Buffalo, and to establish a chain of stations along the entire line.

Long before "wireless" or radio-telegraphy, as it is used today, was much more than dreamed of, the problems of providing telegraphic communication between fixed stations when the lines were in trouble and of communicating with moving railway trains were actively attacked by numerous inventors and engineers. Various plans dependent upon earth conduction, or on magnetic or electrostatic induction, were proposed but none seems to have found its way into practical use. The satisfactory solution of both puzzles was not reached until within the past year, when modern radio telegraphy was attempted to and from a moving train, but now the actual and continuous use of "wireless" on the Delaware, Lackawanna and Western Railroad has demonstrated that telegraph service from point to point and with trains in motion can be maintained even though an entire pole line is swept away by storm.

Late last Summer, when the Telegraph and Telephone Department of the Lackawanna again took up the matter of wireless as an auxiliary to their wire lines, the same two problems were before them. In the hilly districts it had been necessary to use extra heavy line construction with short pole separation, and even this did not give complete protection from storm-made interruptions. In addition there was to be considered the desirability of having direct communication with train crews at all times, so that emergency conditions might promptly be met. On investigation it was found that, while the engineers approached considered the use of radio-telegraphy between stations as a breakdown service to be feasible, much skepticism was expressed as to the possibility of communication with a train in motion. Representatives of one of the German wireless companies even went so far as to say that they had tried this scheme without success, and that it, therefore, could not be done.

Notwithstanding the pessimistic attitude held by some authorities, the Lackawanna proceeded to purchase and install complete radio-telegraph equipments at its stations at Scranton, Pa., and Binghamton, N. Y. Towers were erected and aerial wires stretched as shown in Figs. 1, 2 and 3, and the instruments were put in place within the station buildings. The apparatus at Scranton is shown in Fig. 4, and comprised a 2 kw. 500 cycle quenching gap transmitter, made by the Marconi company, with coupled circuit receiving tuner and crystal detector.

Power for the sending outfit is taken at 60 cycles, 3 phase, from the central station, and drives a Crocker-Wheeler motor-generator giving 2 kw. of single phase, 500 cycle current. Passing through the sending key circuit to a step-up transformer, this 500 cycle current charges a bank of six leyden jars (of 0.002 microfarad each) in parallel. These jars in turn discharge, at each half cycle, across a multiple plate quenching spark gap and through the primary of the oscillation transformer which has its secondary serially connected in the antenna-to-ground circuit. This oscillation transformer is made of two flat spiral strip-copper windings coaxially related and having veriable self-inductance in both windings and variable coupling between primary and secondary. A wave length of about 1,600 meters is generally used, and approximately 12 amp. of radio-frequency current is set up in the antenna circuit. The small power board shown at the left of Fig. 4 carries a generator field regulator and meters for 500 cycle voltage and current, power and frequency, as well as control switches. The Binghamton equipment is identical with this.

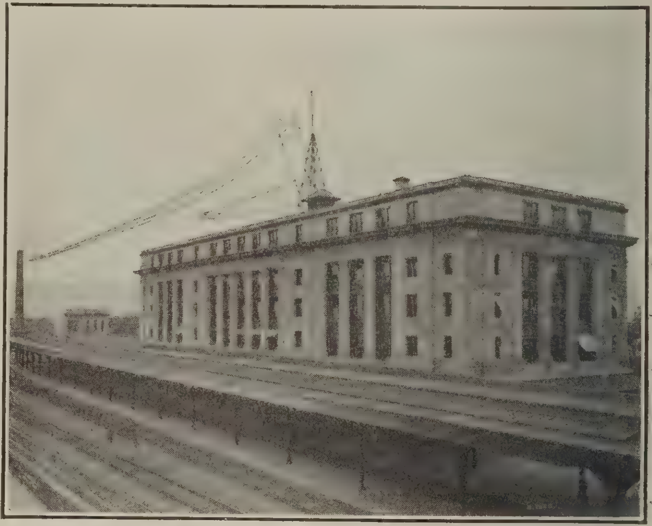


Fig. 1. Scranton Station, Showing Tower and Aerial.

On October 21st, 1913, the radio service was inaugurated by sending the first "wireless" train orders between Scranton and Binghamton, 62 miles distant. The zone of communication was gradually extended, and now includes most of the other efficient radio stations within 300 or 400 miles. The 500 cycle transmitters produce, in the telephones at the receiving station, Morse signals as short and long musical tones of a high pitch having a characteristic piercing quality which permits them to be interpreted through interference from low frequency stations or from atmospheric electrical discharges. The signals as received at Scranton and at Binghamton are so loud that messages may easily be copied directly upon the typewriter.

The utility and reliability of the first two stations proved so great that Mr. L. B. Foley, the Lackawanna's Telegraph Superintendent, soon arranged to place an experimental radio equipment upon the New York to Buffalo "Limited." In making this installation the difficulties of securing electric power for the transmitter, of placing the apparatus and aerial in the limited space available on the train, and of reducing the noise on the train (which it was feared would interfere with receiving messages), had to be overcome. This was not so hard as had been expected, however, since it was found that the 1 kw. 500 cycle motor-generator for the transmitter could be run directly from the storage battery used on the line of the axle-driven car lighting generator, without seriously affecting the illuminating system. By using the walls, a double-decked table and the ceiling, the apparatus (which was made by the Marconi company), was all placed at one end of a car, as shown in Fig. 5.

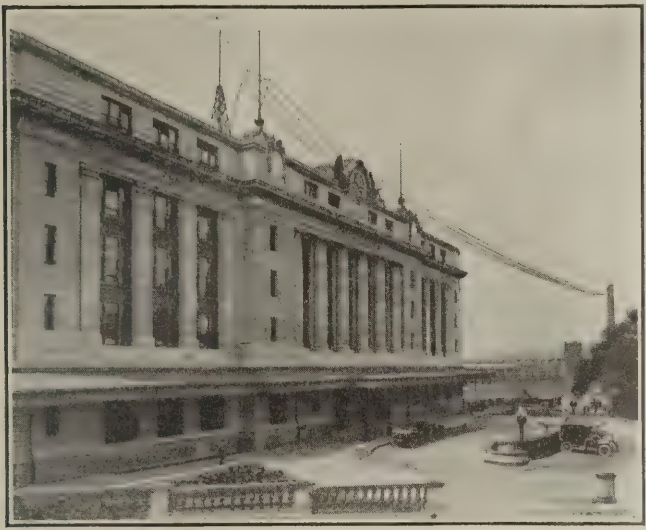


Fig. 2. Scranton Station, Front View.

Instruments similar to those at the Scranton station, but of one-half the power, were installed, except that the motor of the motor-generator was wound for 30 volts direct current, and the 500 cycle current, after passing through the high-tension transformer, charged a battery of only three leyden jars. The meters were omitted from the control panel used on the train, because of the forced economy of space. The aerial wires were strung on insulators around the roofs of each of four cars, on posts about 16 in. high, and the four rectangles so constructed were connected together to form the complete antenna, as Fig. 6 indicates. This small permissible height (about 12 ft. above the rails), is something of a handicap, and must be compensated for by increased power at the transmitter or increased delicacy of the receiver. The noise from wind and rail-joints did not prove so annoying as anticipated, since the high whistling tone of the signals made it possible to read them even when they were quite weak.

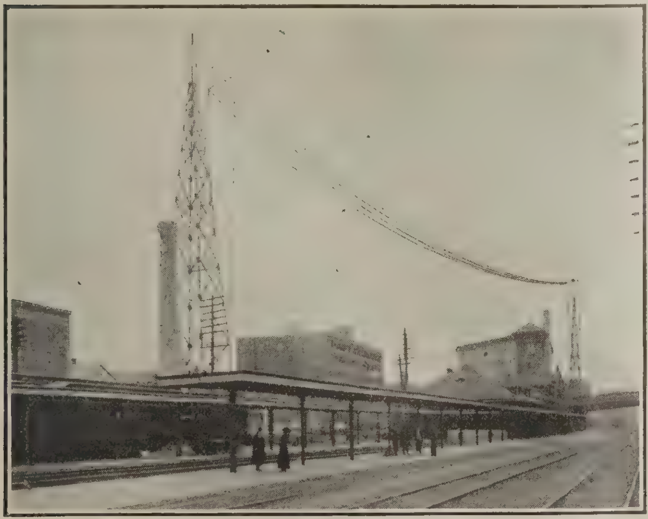


Fig. 2. Binghampton, N. Y., Station, Showing Towers.

Experiments with the train installation began on November 21st, last. At first it was not found possible to work between the train and either of the fixed stations over distances greater than 6 or 8 miles. Even at these small distances certain places along the railroad were discovered where, due to some set of unfavorable conditions, it was not found possible to communicate with the train at all, although in more desirable positions at greater distances good signaling was possible. As the apparatus was adjusted more carefully and as familiarity with it grew, the working distance was gradually increased, until after three or four weeks it was possible to receive signals from the train some 50 miles and to send to it something over 30 miles.

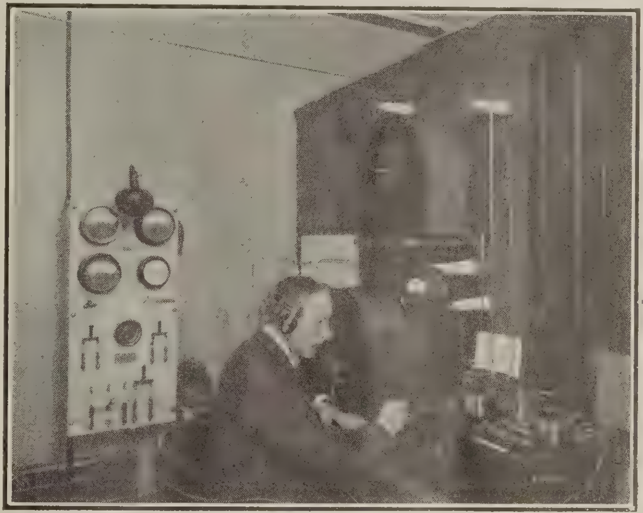


Fig. 4. Instruments at Scranton Station.

These distances seemed to mark the approximate limits of the first installations, but more sensitive and more efficient receivers were purchased from another radio company and, when installed, made it possible to telegraph to or from the train well over 100 miles. The communication distance will be still further increased by the installation of higher powered transmitters at future stations. The 5 kw. transmitter of the Brooklyn Navy Yard station has been received on the train as it left New York until Scranton was nearly reached, a distance of about 140 miles.

When radio work was begun on the Lackawanna the two uses for which it was expected to be valuable were, first, as an auxiliary to wire lines in case of circuit difficulty and, second, as a means of reaching trains while under way between stations in times of emergency. No sooner had the service been opened, however, than many additional applications came up, to the surprise and gratification of the Telegraph Department officials. On November 24th, a week after the first test, with the train installation, the conductor was taken ill when about 30 miles from Scranton on the West-bound trip. Without the "wireless" it would have been necessary to hold the train at Scranton until another conductor could be located and pressed into service, or else to stop the train and telegraph ahead to arrange for the relief man. With the new equipment, however, a radiogram sent ahead was sufficient to have the substitute ready at Scranton, and the "Limited" continued its trip with no loss of time.

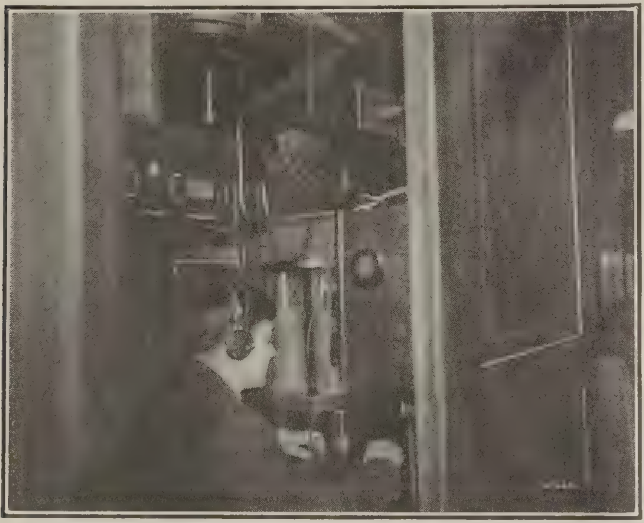


Fig. 5. Apparatus Aboard "Lackawanna Limited."

During the next month, December, a locomotive attached to the limited train broke down, and another was ordered by radio without the delay which would have been brought about by looping in on a telegraph wire and establishing communication in the old-fashioned way. An ambulance and physician were ordered to wait at the station for a passenger who had an epileptic attack and required immediate medical attention in a case where minutes might have meant the difference between life and death. Two tramps who were attempting to travel by the blind-baggage route were met at Scranton by a police officer who had been called by radio. Press dispatches were sent to the train and distributed for the information of the passengers en route. Passengers arranged appointments at places along the line by radio when it was not possible to do so by wire because of the long runs which the fast trains make between stops. Additional coaches to accommodate unexpectedly large passenger traffic were provided at one station upon orders transmitted after the train had left the stop just preceding, with none of the wasted time which would have been a necessary consequence without the "wireless."

All the above relates to the moving train equipment, and new uses for this are found almost daily, since good communication can be maintained even at the highest train speeds. As to the fixed stations themselves: In December a sleet storm paralyzed the wire service between Scranton and Binghamton, but did not disturb the "wireless." Until the wire circuits were again closed, one by one, beginning two hours later, the only way to signal between these points was by radio-telegraphy, and in this time 54 train orders (which otherwise would have been held up) were transmitted.

In the wet-snow blizzard of March 1st and 2nd, 1914, which completely tied up all railroad travel and wire signaling traffic in the East, the Lackawanna suffered heavily by total loss of poles and lines for 40 miles east of Dover, N. J. But "wireless" communication was immediately established between Scranton and stations in New York, and the next day, March 3rd, a temporary radio installation was put into service at the Hoboken terminal. On that date the equipped train, No. 3, went through from New York to Buffalo only 55 minutes late and, en route, reported by radio line conditions to officials at both ends. A temporary station was installed at Dover also, and for five days the "wireless" gave the only means of communication between Hoboken and Scranton. Satisfactory wire service through emergency cables laid along the right-of-way was not established until five days later, and in this interval of 10 days the radio-telegraph equipments handled 1,125 messages, many of which checked over 50 words each. By this use of radio it was possible to resume the train schedules 48 hours earlier than would have been possible by the wires alone, and thereby a great saving was effected. The Lackawanna "wireless" was of material assistance to other railroads also, and the Lehigh Valley, Erie and New Jersey Central companies were enabled to report conditions to their New York offices by way of Scranton.

So much for the actual accomplishments of radio-telegraphy in its first six months of commercial use on railroads. The Lackawanna officials are so firmly convinced of its practicability and value that they are proceeding with the construction of a chain of stations along the entire line. New permanent installation will be made at Hoboken and Dover, N. J., and at Port Morris, Bath and Buffalo, N. Y. The railroad does not intend to purchase all of its radio apparatus from any one radio company unless that concern can demonstrate the unqualified superiority of its instruments. The first importance is attached to reliability and operating efficiency, and it now appears that no one company is in position (on account of patent and similar rights) to furnish not only the best transmitters, but also the best receivers and auxiliary appliances.

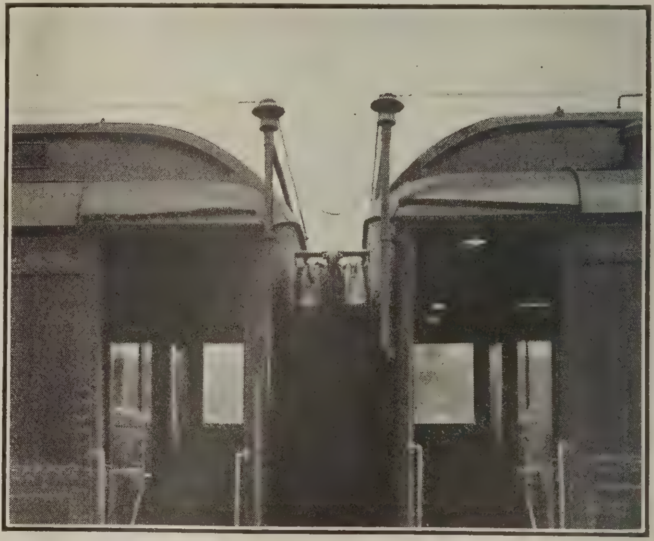


Fig. 6. Portion of Train Aerial, Showing Flexible Link Between Cars.

It is anticipated that radio-telegraphy will prove of more and more importance as its use extends to the equipping of through freight trains (which thus can receive orders without incurring the large expenses incident to the stopping and starting of such heavily loaded rolling stock), wrecking trains and the like. Experiments in the control of switches and signals by radio are going forward, and radio telephony has been tested at some length between Scranton and the train.

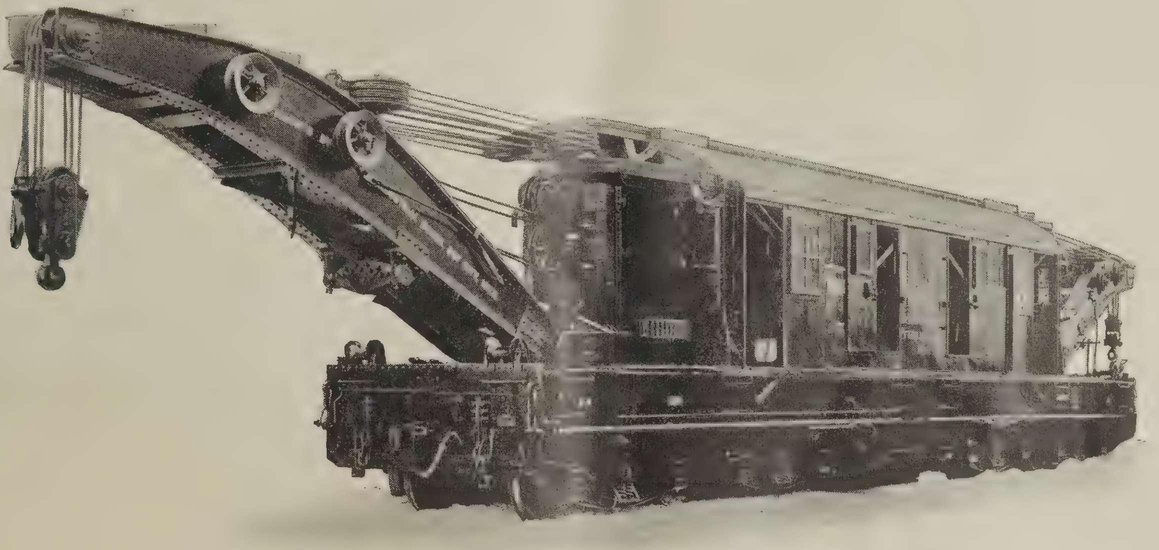
Installation of apparatus on the second "Limited" has been held back pending completion of these trials, since, if telephony can be used, the expense of an operator on each train may immediately be eliminated.

It is also proposed to use radio-telegraphy for direct communication between Hoboken and Buffalo instead of running the additional wire line which recent growth of telegraph traffic now makes necessary.

The advantages of "wireless" which bring up this new method for such consideration are that tower and aerial installations may easily be built so as to withstand storms which entirely disrupt wire service, and that all maintenance expense is concentrated at a few definite points instead of being spread out over a long line which requires continuous watching and repair. The progressive spirit of the Lackawanna is becoming as evident in this matter of radio as it was in connection with telephone train dispatching some years ago, and, from his experience, Mr. Foley, superintendent of telegraph, now says that not only does "wireless" permit the dispatcher to board every train but also that the total loss of communication between stations, caused by prostration of poles and wires, is a thing of the past.

100 Ton Electrically Operated Tunnel Crane

Special crane designed for tunnel use; to be operated electrically, both for self propulsion and hoisting; takes power either from third rail or from storage battery on locomotive. Motors aggregate 1,100 *h.. for traction and hoisting. Will haul* 80*-ton rolling load at* 25 *miles per hour on level track. Capacity,* 100 *tons at* 24 *ft. radius.*



Electrically Operated Locomotive Tunnel Crane. Note That Each End of Locomotive Is Equipped with Crane. A Storage Battery Is Mounted on the Locomotive Which Makes It Possible to Operate Independently of Third Rail Power from 2 to 8 Hours.

A noteworthy piece of equipment for use in case of accidents or wrecks within the Grand Central Terminal has been received recently in New York. This appliance is a double end electric wrecking crane, with independent 100-ton capacity cranes at each end, the whole being especially designed for the underground clearances and conditions existing in Grand Central Terminal. While primarily designed to meet Grand Central Terminal conditions, it is also adapted for use on the main line of the electric division, where operating conditions and clearances are such as usually obtain on steam roads. This machine may be dispatched at high speed under its own power to the scene of an accident anywhere on the electric division. In fact, it combines the functions of a crane with many of those of a high power eletcric locomotive. It is completely equipped for high speed, independent operation, with air brakes, whistle, and all necessary fittings.

Just as operating conditions in Grand Central Terminal are different from those found elsewhere, so is this crane which was designed to meet those conditions, unusual in its features. Nowhere else in the world can be found a crane so well fitted in power or ease of operation for this class of work. The procedure in case of a wreck underground would be somewhat as follows: If possible, the wreckage would be lifted clear of the track and the crane would then back out with it. However, if the crane could not raise the damaged equipment off the track—either on account of lack of head room or because of the size of the piece—one end would be lifted with the main hoist and with the auxiliary hoist, a special truck would be placed in under. The crane would then drag away the load.

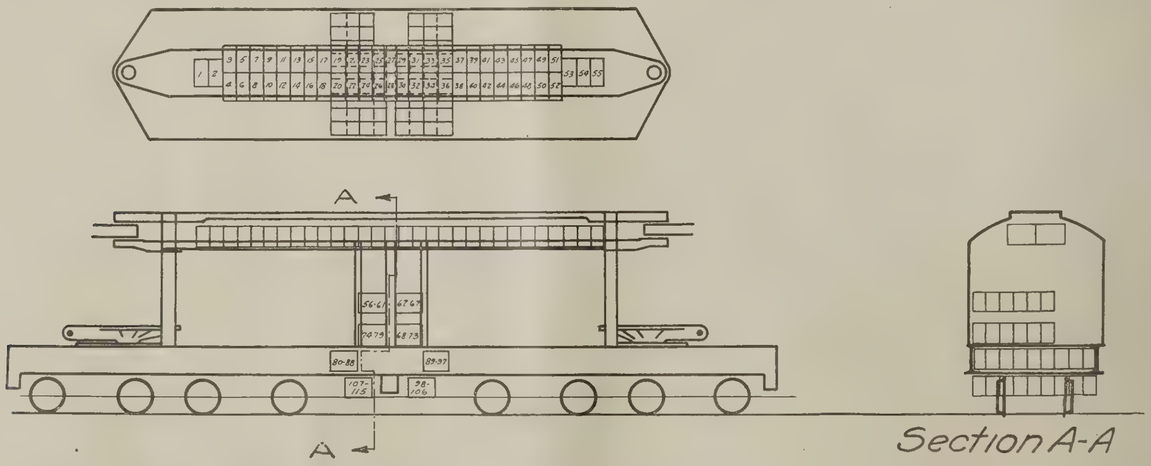
Mechanical Features.

In construction the crane is unusually massive and of great strength. The car body is 67 feet long, with a wheel base of 51 feet, and is carried on two compound trucks, made up of two four-wheel trucks each. A cradle on which the car body rests allows the compound trucks, as well as each single truck, to have perfect freedom to swing when taking curves. Complete air brakes are provided, also a hand brake wheel at each end. There is a comprehensive system of air-operated telescopic outriggers or jack beams, used to add stability during heavy lifting and to distribute the load over a greater area. These are controlled by valves with suitable levers, and are instantaneous in action, thus combining ease and speed of operation.

At each end of the car is a complete independent crane, with a structural mast and boom, accurately turned roller path and rollers, and the slewing mechanism. All of the motions of operation may be performed independently, and with loads up to the capacities of the motors may be performed simultaneously. A special feature is the air operation of all clutches to insure quick and sure engagement and release. Such a system with suitable levers is at both ends of the car, each operating its respective end, except for the propelling, which may be controlled from either end.

Electrical Equipment.

The electrical equipment is noteworthy, not only on account of the power it develops, but because of its flexibility. Six principal motors with a total of 1,100 h.p. are used for operating the crane, as follows: Four of 200 h.p. each for propelling, and two of 150 h.p. each for hoisting and for operating the machinery. The propelling motors are direct connected to the axles of the compound trucks, two at each end of the car. They are arranged so that all four may be used for traveling, or if desired, only the two at either end. They are capable of operating safely on fluctuations of line voltage between 300 and 750 volts, d.c. Control is from each end of the car, the controllers being arranged for connecting the motors in series, series parallel and parallel. There is also an electrically driven air compressor.



Showing the Location of the 230 Storage Cells. Crates as Numbered Are Double Compartment Tanks. Battery Will Operate Locomotive Independently from 2 to 8 Hours.

For intermittent and emergency service, as might be required with the third rail out of commission, or when suitable cable connections could not be made with a feed line, there is installed on the crane a high capacity storage battery. This is ready for instant service to operate the crane independently of any outside source of power. It consists of 230 U. S. L. cells, and has a capacity of 75 amperes for 8 hours, with a maximum discharge rate of 350 amperes for 2 hours. There is a complete testing and charging outfit, in order that the battery may be charged anywhere that connection can be made with a feed line. At each end of the car is installed a switchboard suitably equipped with lamps and instruments, including an ampere-hour meter for use with the storage battery.

Operation of the Crane.

The operation of hoisting is by means of a train of cut spur gearing. There is a brake of sufficient capacity to hold the maximum load in any position, or to lower it at a low rate of speed. A combination clutch and brake is provided for dispatch lowering of the block. In addition, there is a ratchet and pawl of ample strength to hold the maximum load when the clutch is disengaged and the winch heads are in operation. These winch heads are on either side of the crane, are of 25 tons capacity, and are independent in operation of all other mechanisms.

With all four propelling motors in use, the crane was guaranteed to travel at the following speeds:

Hauling an 80-ton rolling load: 25 miles per hour on straight level tracks; 15 miles per hour on a 2.7% grade; 12 miles per hour on straight level tracks with the addition of a 50-ton suspended load.

As a matter of fact, actual speeds greatly in excess of these were attained. At the formal test conducted by the railroad officials, the crane propelled itself at a rate of 34 miles an hour while hauling an 80-ton rolling load. Satisfactory operation is also possible using only the two motors at either end of the car, with resulting speeds of about 60% of those when all four motors are used.

In general the following capacities are provided for:

On solid foundation with outriggers: 100 tons at 24 ft. 2 in. radius straight ahead or 6 ft. 6 in. either side of center; 100 tons at 22 ft. 0 in. radius straight ahead or 12 ft. 0 in. either side of center; 100 tons at 13 ft. 8 in. swinging 180 degrees.

Without outriggers: 50 tons at 24 ft. 2 in. radius, straight ahead; 25 tons at 13 ft. 8 in. swinging 180 degrees.

This crane was designed and built by the Industrial Works, Bay City, Mich., from specifications prepared by a committee consisting of H. A. Currie, assistant electrical engineer; B. S. Buell, wrecking master, and C. H. Quereau, superintendent electrical equipment, of the New York Central & Hudson River Railroad.

Home Made Electric Locomotive.

The Quebec Railway Light & Power Company has built an electric locomotive which was primarily designed for freight service but is also used for hauling from 8 to 10 passenger cars when required.

It is 34 ft. long over all, 8 ft. 8 in. wide, weighs approximately 98,000 lb. and has two trucks of 6½-ft wheelbase, 28 ft. 8 in. center to center.

The equipment consists of four Westinghouse 303-A motors, geared 16:61, and an L-4 controller which is placed in the center of the steeple cab. The normal speed is 18 m. p. h., and on a level the train will haul 400 tons at 10 m. p. h. Resistances and other equipment are carried under the sloping ends. Westinghouse air brakes are used.

Penn. R. R. Suburban Electrification at Philadelphia

Section to be electrified at present 21 miles four-track suburban line. Single phase trolley system selected on account of its flexibility of overhead and transmission equipment and also because it can be used with any of the existing types of motive power. Electrically equipped standard coaches will be operated on multiple unit system. This will reduce the number of train and locomotive movements in and out of the Broad Street station and relieve serious congestion at that point.

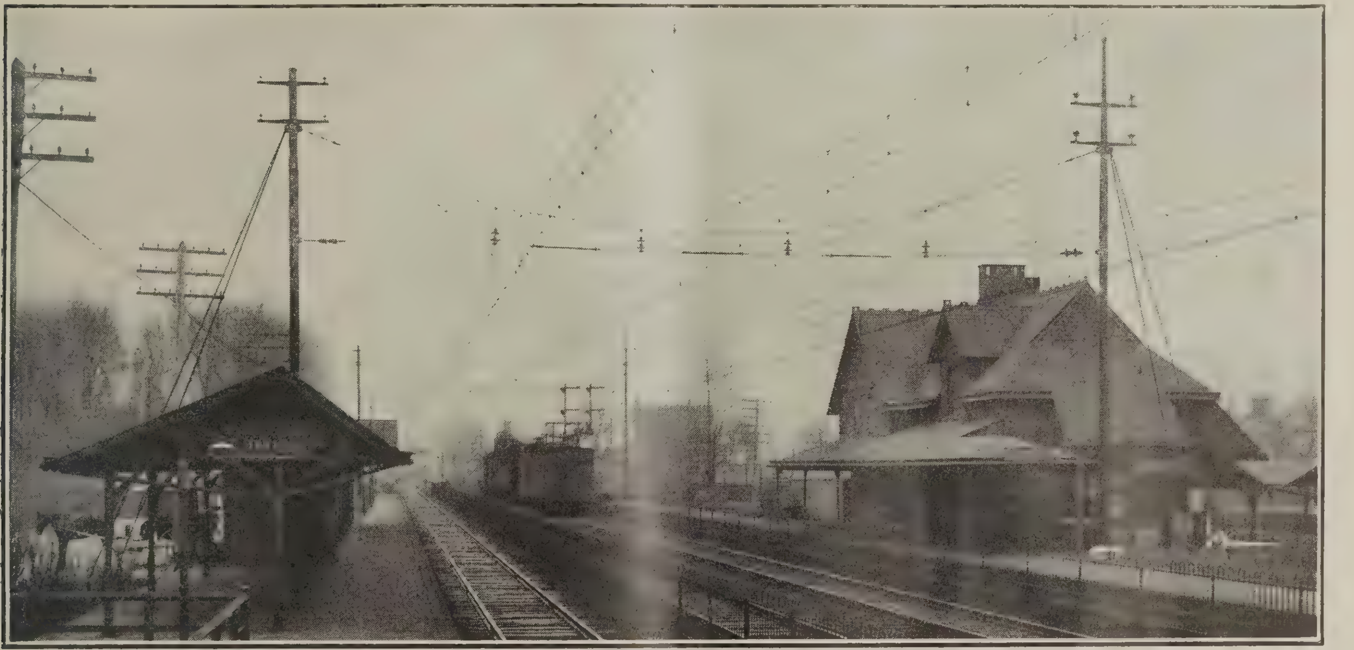


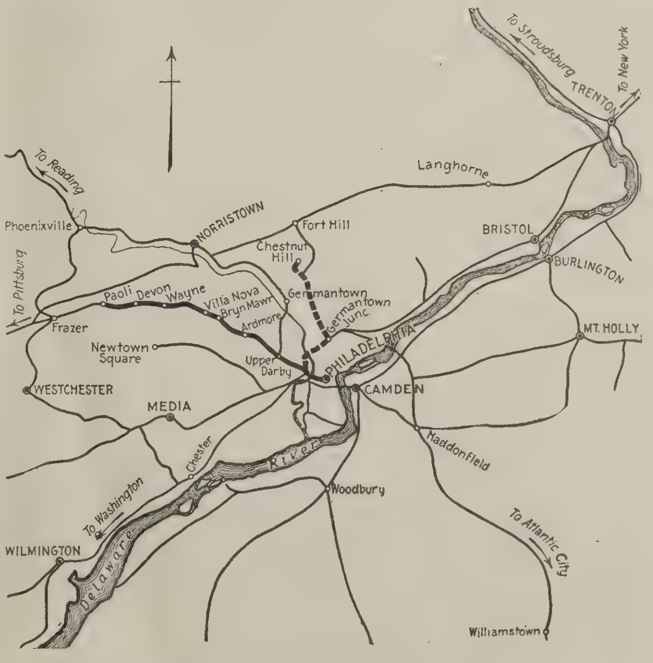
Fig. 1. Section of Suburban Line Near Philadelphia. Equipped with Experimental Overhead Construction. Note the Different Types of Catenary Support. The Double Trolley Shown on First Track Is Type Adopted.

At the recent meeting of the New York Railroad Club, Mr. George Gibbs briefly outlined the present plans for the electrification of the Pennsylvania Lines at Philadelphia. Although at the present time it is proposed to electrify simply the Paoli suburban service, the matter is of unusual importance, first, because of the selection of the single-phase system of operation for suburban traffic, and second, because of the fact that this is but the beginning of the vast electrification scheme of the Pennsylvania Lines.

Reasons for Electrification.

The traffic in and out of Broad St. station, Philadelphia, has reached the limit possible under existing terminal facilities, so it is necessary to consider either the proposition of increasing the size of the station or introducing electrical operation for the suburban traffic. The latter plan has been decided upon because there will then be a return in decreased operating expense to pay interest charges on the cost of installation. With the increase in size of station there would be no such decrease in operating expense, in fact, rather an increase would be experienced.

As pointed out by Mr. Gibbs, there exists a point of concentration or a "neck of the bottle" just outside of the Broad Street station, where six suburban lines cross. This limits the number of trains it is possible to handle in and out of the station. By employing electrically operated trains of the multiple unit type, however, it will be possible to decrease the total number of movements through this throat, since it will then be possible to simply double-back out of the station on a new run without sending either locomotives or empties to the coach yards. There are at present 47 outbound trains and 49 inbound and this frequent schedule must be arranged so that the suburban traffic is sandwiched in between through



Map Showing Electrified Section.

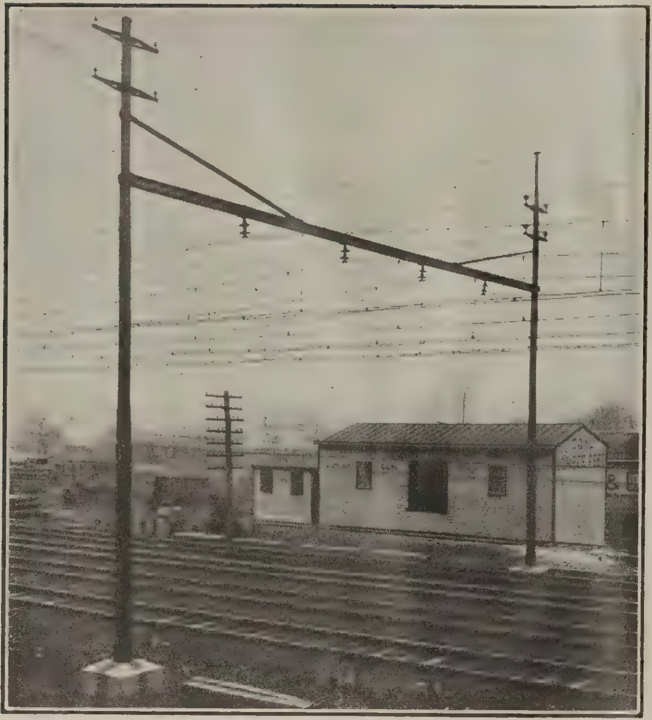


Fig. 2. An "I" Beam Transverse Support with Double Insulator Flexible Hangers for Catenary.

train service which consists of 33 outbound and 36 inbound trains, making a total of 165 trains daily.

The suburban line to be electrified has four tracks, and when the trains are past the congested section the operating difficulties are by no means serious. The suburban traffic over the main line west is at present handled in three-car trains during non-rush hours, and in five and six-car trains during rush hours. These small trains are hauled by passenger locomotives of nearly the largest type in use on the Pennsylvania Lines, so the great excess of power available in the locomotive is made use of in producing rapid acceleration. The average schedule speed from Philadelphia to Paoli is 21 miles per hour, which includes 19 stops.

The decrease in train movement through the throat section of the terminal, as outlined above, will be between 16 and 20 per cent. where the suburban trains are operated electrically. In addition it has been found that by using the multiple unit train there will be the equivalent of two extra platform tracks gained in the station, since the space occupied by the locomotives will be eliminated and because the electric trains can be made ready for a return trip promptly upon arrival at the station. This amounts to an increase of 12½ per cent. in station capacity, which, together with the decrease in train movements through the throat of 16 to 20 per cent., will be sufficient to take care of the normal increased traffic for the next six years.

Single-Phase System Adopted.

The single-phase system of operation has been adopted for this electrification, not so much with the idea of meeting the special conditions of suburban service, but rather with the idea of being a logical step in extensive plans for electrical operation between New York and Washington, as this is really the initial installation of the comprehensive plan of electrical operation, the whole subject has been given a very thorough investigation for the past few years by Gibbs and Hill, consulting engineers for the Pennsylvania R. R., and the selection of single-phase system is as a direct result of these investigations. Moreover, it is a point worthy of note that the system adopted, employing overhead trolley construction, may be readily employed with either single-phase, split-phase or a.c. d.c. rectifier locomotive.

Overhead Construction.

An extensive series of tests to determine the most desirable type of overhead construction has been carried on over a mile of the section to be electrified, and during this series of tests numerous types of catenary construction and transverse supports were investigated. Tests were made on the mechanical features of the construction only; a special test car was constructed with observation platform on the roof, and this was drawn at

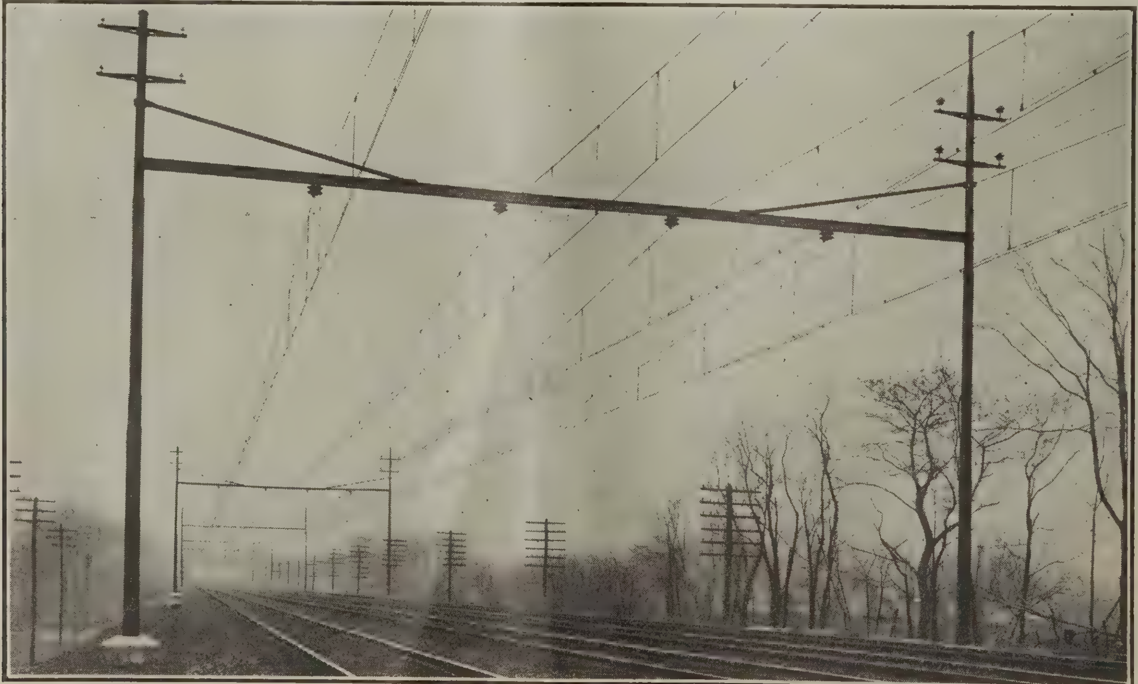


Fig. 3. Transverse "I" Beam with Rigid Insulator Supports for Catenary. Double Trolley Shown at Left Was Type of Catenary Selected. The Transverse Catenary Cable Supports as Shown in Fig. 5 Were Selected in Preference to Transverse "I" Beams as They Offer Less Obstruction to Signal Indications and Are More Flexible and More Easily Installed.

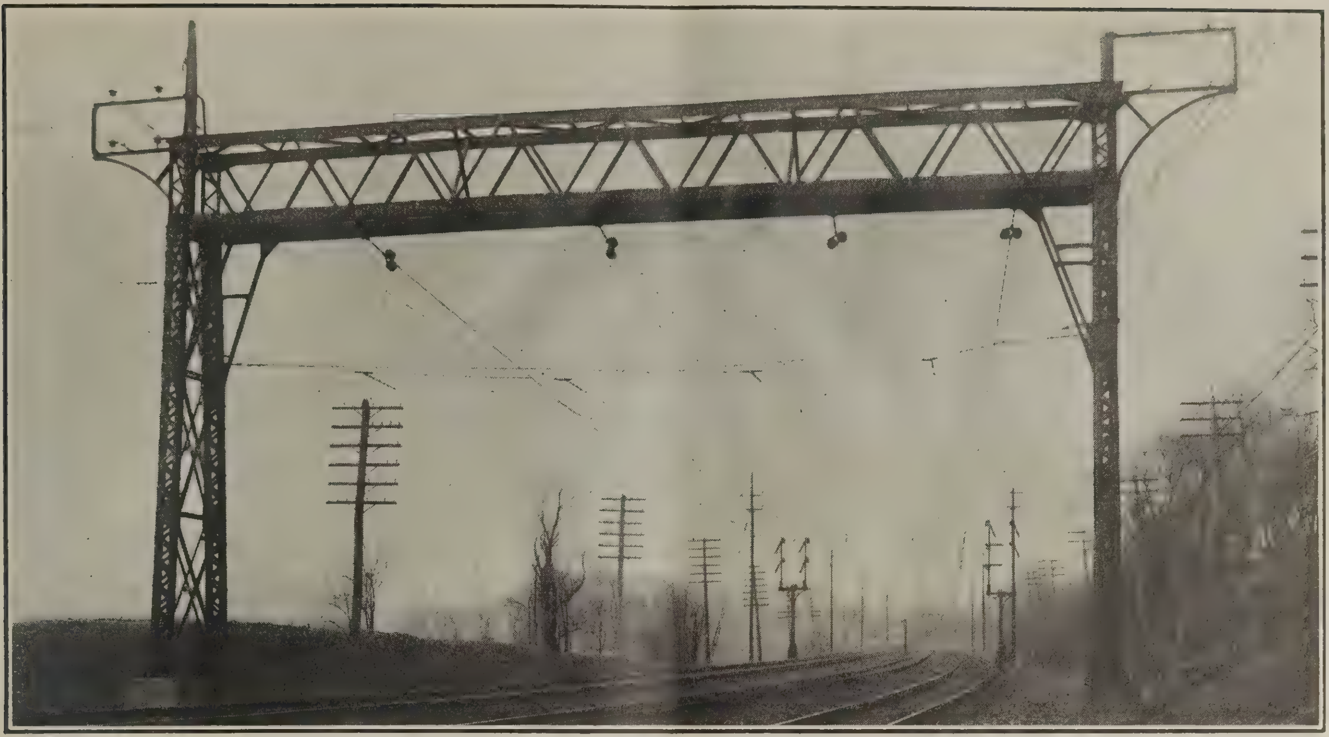


Fig. 4. Trolley Anchor Bridge Installed Every Half Mile.

high speed by steam locomotive so that the mechanical operation of pantograph roller on the trolley could be observed. As a result of these tests it has been decided to employ the double trolley fastened together by clips at 15 ft. intervals and supported by single hangers connected to the top wire midway between every second pair of clips, or at intervals of about 30 ft., as shown in Figs. 1 and 5. By employing the double trolley, which is supported by the top wire and contact made with the pantograph on the bottom, the maximum flexibility is obtained. Although this system is not entirely new, the feature of supporting it between every second pair of clips is employed here for the first time.

Two general forms of transverse catenary supports have been tried out. One of these consists of a transverse bar, an 8-in. "I" beam, supported at either end by steel poles by diagonal tee bars. The longitudinal catenary construction is suspended from insulators attached to this "I" beam, as shown in Figs. 2 and 3. Another form of transverse supports, and that finally adopted as the most suitable for this purpose, consists of a cross catenary cable, which replaces the "I" beam. Insulators are suspended from this cross catenary cable, which support the main catenary of the line system. These insulators are also guyed to the poles by a straight horizontal cable with insulators, as shown. Suitable insulators are provided in this horizontal steadying guy to insulate all of the trolleys from each other so that each

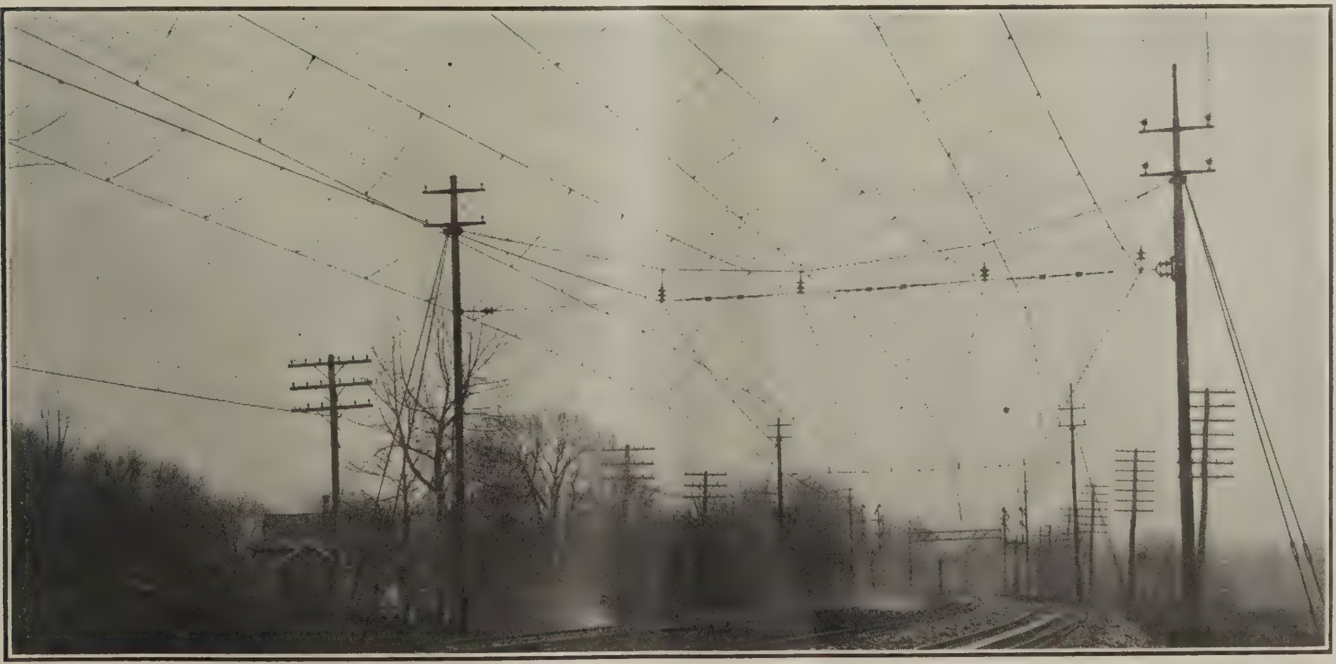


Fig. 5. Showing Approved Method of Transverse Catenary Support on Curves. This Method of Cable Support Has Been Selected in Preference to the Transverse "I" Beam Shown in Previous Illustrations.

line may be operated independently. The wooden insulators employed for this purpose are about 3 ft. long with three of each and two composition strain insulators between each section. Some of the sections of the track during test were equipped with a single contact wire supported from the catenary both by solid rod hangers and by light flexible cables.

On straight tangent the poles will be placed at intervals of 300 ft. and on curves, as required in each particular case. The catenary construction on curves is admirably shown in the accompanying illustration, Fig. 5. This type of transverse cable support has never been used for four track main line in this country before. It has, however, many advantages in the ease of erection, reduction of maintenance cost, and first cost, but the main advantage is that the installation of transverse cables instead of steel bridges obstructs the view of the motorman but little, and consequently interference with signals is minimized.

Single-phase power will be transmitted along the line at 33,000 or 44,000 volts and be reduced to 11,000 volts for the trolley at the three transformer stations along the line. Power is received from the Philadelphia Electric Co., at one of these stations, and here transmitted from 13,200 volts to the transmission voltage required for the railroad line.

Car Equipment.

For the present, at least, no electric locomotives are to be operated over the electrified line, the suburban cars operated over this division being self-propelled units, consisting of a standard coach of the type M.P. 54, which are already in extensive use. These cars were originally designed and built with regard for future use as electric motor cars, and are equipped with a suitable installation of conduit. They are 65 ft. long, with seating capacity of 68. The weight of the car body is approximately 64,000 lbs., and of the two trucks 33,000 lbs. The weight of the electrical equipment installed will be approximately 30,000 lbs.

One truck only will be supplied with motor equipment, which will consist of two 225 horse power single-phase commutator type motors. Multiple unit control with controller located in the vestibule will be provided, the latter being protected when not in use by the end door which opens inwardly.

It is estimated that 100 motor cars will be required for this service, and these will be provided by converting a similar number of M.P. 65 coaches now in service or on order. The motor trucks will be built by the railroad company in its own shops, and the equipment for them will be purchased within a short time. Current for the cars will be collected from overhead trolley by pantographs, one of which will be installed over the truck at each end of the car. High tension current will be carried by heavily insulated cables in conduit to a single main transverse located beneath the car and from this current will be supplied the motors at about 320 volts.

Cost of Power for Compressing Air

H. R. Bucks, Chief Elec., Oregon Short Line

In many large railroad shops air compressors consume one-third of the total steam generated. Author shows detail costs of compressing 1,000 cubic feet of air with steam driven compressors and deduces that in order to show economy with electric driven compressors, power must be purchased at less than $0.0042 per kw.-hour.

It is suggested that by making a special arrangement with the local electric power company, so as to run the compressor at off peak periods, a rate lower than this might be obtained. Economy in the use of compressed air is suggested by replacing air by electric driven tools.

The steam operated air compressor is such a fixture in the power house for railroad shops and terminals that we are apt to accept its necessity unquestioningly in a good deal the same way as the majority of our ancestors unthinkingly regarded the "Divine Right of Kings." Long existance of a condition has a tendency to discourage change. However, as excessive taxation had a good deal to do with the downfall of kings so the steadily increasing burden of steam required to operate air compressors at length has reached a point where it is apparent that relief must be obtained.

I do not wish to give the impression that a condition has been permitted to exist in railroad power houses until it has literally compelled an effort to regulate the cost. Carefully kept records of cost of operation, repairs and fixed charges incidental to the operation of railroad power houses have revealed this condition for some years. This question has repeatedly engaged the attention of motive power and machinery officials during this time. However, the remedy is not so apparent as the need.

It has been customary with railroads to locate steam driven air compressors in the main shop or terminal power house. From here air is piped to points required, due consideration being given the need for reservoirs which are located so as to supply the greatest sudden demands with the least fall in pressure. This arrangement has permitted the use of exhaust steam from the compressors for heating nearby shop buildings and roundhouses in the winter.

Of late years the growth of demand for steam to operate the compressors has exceeded the increase in steam required for operating electric generators. It may be somewhat startling to state but it is nevertheless a fact that the compressors in one of the shop power houses of a western railroad require 30 per cent of the total steam generated, whereas the engines driving the electric generators require but 20 per cent. This in a large shop with all machinery electrically driven and full equipment of overhead traveling cranes, etc. Complete lighting and power provisions for extensive freight, terminal, passenger station, commissary and laundry. In addition, power is furnished for battery charging for automatic block signals on one division and power is furnished the substation for A. C. transmission line operating the block signals for a portion of another division. Something over a milmion kw. hrs. are generated annually in this power house and yet the air compressors use 50 per cent more steam than do the steam driven generators.

Freight trains have the train line charged, the brakes tested and, if necessary, repaired before road engines are coupled on and air is piped in some cases a mile under ground for this purpose. Compressed air is used for cleaning passenger cars in a somewhat wasteful manner and trucks and other gear beneath these cars are blown clean and sprayed with oil. A considerable amount of air is used for blowing flues of locomotives in the roundhouse. It is somewhat difficult, however, to account satisfactorily for the rapid growth in the demand for air. It is such a useful commodity and where at present used, serves its purpose so admirably that we hardly feel justified in discouraging its use or advocating a substitute except where portable drills can be operated by electricity, as well as and more economically than by air. We turn rather with increased vigilance to curtail the waste in the use of the air and then seek a method for reducing the cost of production.

Electric power can be purchased for a figure much lower today than has even been the case in the past. After an advantageous contract has been arranged for the purchase of electric power in lieu of generating it the superintendent of motive power naturally raises the question as to whether electric power and motor drive for compressing the air will not be desirable. At first thought it would seem that electric drive would be cheaper than steam, particularly as the former may, if the power is purchased, be favored with the omission of fixed charges for boilers, steam piping, etc., and that portion of the building and grounds occupied by the steam generating equipment.

Comparison of Steam and Motor Driven Compressors.

We must base an opinion on a fair comparison of the cost to generate steam as compared with the cost of electric power to perform the same operation or amount of work, namely, compressing 1,000 cubic feet of free air. This comparison really involves all losses in compression of the air and will at once express the degree of economy obtained if electric power is used.

The first fact to be accurately determined is the actual cost of generating steam which is at present furnished the compressors.

(1) Coal is charged at mine cost plus commercial freight if hauled over foreign roads, or plus five mills per ton mile if hauled over the same line entirely that operates the terminal. To this is added the labor cost of unloading.

(2) Water for steam is charged at actual cost to deliver it at the power house.

(3) A steam consumption test of the air compressor supplemented by evaporation test of the boilers must be run and a record of the cubic feet of air compressed during the period the costs are to apply must be known. From this data the percentage of the total coal delivered to the power house which is used by the compressor is determined.

(4) This percentage is applied to:

(a) Total boiler room labor.

(b) Repairs to all boiler room apparatus including steam pipes.

(c) Repairs to boiler room portion of building and stack, coal bunkers, etc.

(d) Fixed charges made up of interest, depreciation and taxes on original cost of boiler room equipment, steam pipes, stack and portion of building and grounds occupied by same.

With the above data known the cost of steam per 1,000 cubic feet of free air (recorded as piston displacement) may be stated, as for instance the following:

7½ lbs. steam per pound of coal (stoker firing).

104 lbs. of steam per 1,000 cubic feet air compressed.

Cost of steam is in this case $0.0115 per 1,000 cubic feet air compressed.

The proposed motor driven air compressors will require 2.6 kw. hours to compress 1,000 cubic feet of free air (as recorded by piston displacement). $0.0115 divided by 2.6 gives $0.00442 per kw. hour for which electric power must be delivered to the motor driving the compressor to equal the cost of steam as at present generated.

A favorable contract for the purchase of electric power on a load factor basis might enable the railroad company to obtain such a rate if one or two large compressors with mechanical unloaders are run continuously in conjunction with a smaller compressor operated by an automatic self starter controlled by air pressure to supply the peak loads of air demanded.

However, it is obvious that little more can be expected from electric drive in this case than just to equal the cost of steam. It is desired that a more subsantial gain may be shown in favor of a plan for relief.

In spite of the low cost of operation per unit of output shown to be obtained by the steam driven compressor the fact remains that the total cost of operation must be reduced.

Economy Effected by Replacing Air Driven Tools with Electric.

It is suggested that wherever possible, electrically operated portable tools be substituted for pneumatic. Electric drills are balanced better and therefore easier to handle.

"Drilling a ¾-inch hole 1 inch in depth per minute in steel requires .55 to 1.95 H. P. input with electric portable drills. This would require at least 25 cubic feet of air per minute and power required at the cylinder of the compressor to deliver this quantity of air at 90 lbs. pressure is 4.25 H. P." (*June*, 1912, *issue, Electric Journal.*)

In addition to being more economical to operate there is a smaller loss in transmitting electric power to these tools than there is in transmitting the air, even if there were no air leaks, and portable electric wire lasts longer and costs less than air hose.

As the shop has extended the air piping has lengthened. The mile long pipe to the freight yard is recalled. In the winter frozen moisture in this line sometimes prevents more than fifty pounds pressure being obtained at the freight yard, which is valueless.

It is determined to eliminate all these long underground air pipe lines and transmit electric power instead and locate 300 cubic feet per minute capacity motor driven compressors—one at the freight yard, one at the car shop and rip track, and one at the coach cleaning track. 2,200 volt transmission lines are to be installed under ground from the power house to the compressors and transformers, stepping down the voltage at the compressors to 440 with a slip ring type of motor driving compressor by means of herringbone gear with compressor fully enclosed and self-oiling throughout and self-starting, being controlled by air pressure (carbon pile starting resistance).

A graphic recording wattmeter (portable) will indicate at once whether each compressor is provided with sufficient reservoir capacity.

It is estimated roughly that the above arrangement will reduce the air compressed in the main power house one-half and give much better pressure at the distant points.

The motor driven compressor described has proven eminently satisfactory for smaller engine and freight terminals.

The discussion of self-starters versus mechanical unloaders and the experience of the railroad company in securing guaranteed economies based on specified conditions of operating, together with statement of tests run after delivery of the compressors, may form a separate article.

The above question is particularly pertinent when the growth of shops demand more boilers and larger compressors. It is real economy when first cost and operating expense may both be reduced.

This article was intentionally written to lead one to expect that electric power completely replaced steam in operating compressors. That was the expectation on the part of the investigators before actual operating costs were applied to the problem.

In that respect the article pictures the frame of mind in which the investigation was made. It strengthens the conclusions somewhat to realize that preconceived ideas or expectations were disproved and relinquished.

New Battery House for Soo Lines

J. R. Smith, Chief Elec. M. S. P. & S. S. M. Ry.

Unusual feature in this installation is that no special attempt is made to protect steel structure, overhead or conduit; it is simply painted with white lead. No corrosion in seven months. This is probably due to the excellent ventilation provided by metal sash, with 30% ventilation, entirely across each end and one side of building.

Special plugging-in box is installed for making circuit connections. Carbon pile rheostats used for controlling charge on switchboard.

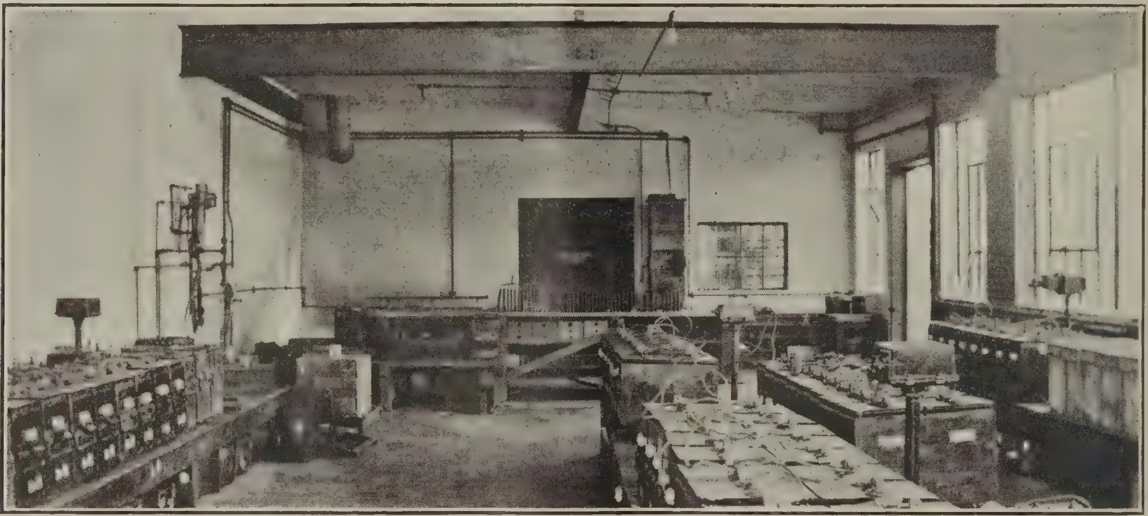


Fig. 1. Interior of Battery House Showing Cleaning and Charging Benches. Note the Exposed Steel Work Overhead. Excellent Ventilation, However, Is Provided on Three Sides. Rochlitz Water Still Shown on Wall at Left. Note Charging Receptacles at Various Points.

The Minneapolis, St. Paul and Sault Ste Marie Ry. have recently completed a battery washing and repair plant at their Shoreham Shops, Minneapolis, which has some features of special interest. The building is in addition to the present car shops and is 30 by 92 ft. It is entirely constructed of brick and the roof structure is carried upon steel "I" beams set into the walls. Metal sash with 30% free ventilating openings, extend entirely across each end and one side of the structure and all doors are covered with metal according to the usual fireproofing practice. It will be noted that this is entirely contrary to the usual battery room practice in permitting of exposed metal overhead. This metal work is simply given a few coats of white lead. It may be due to the unusual ventilation provided, but at least is in part due to the use of the white lead paint, that no corrosion has taken place during the seven months of service with almost constant battery charging during that period.

The flooring is an acid proof material, arranged for drainage to the sewer so that it can be flushed daily without inconvenience to the workmen. All drainage from floor and washing table is carried away in vitrified ducts.

Battery Cleaning Table.

A battery washing table consists of a lead covered top 22 in. wide by 13 ft. long and 40 in. above the floor level which drains into the sewer system. Along one side of this top and across one end are provided benches at a height approximating that of the floor of the battery boxes upon the cars, batteries are delivered on this bench where connectors are removed and thrown into a soda bath, covers are steamed off and placed in hot water for thorough cleaning, elements are removed and placed on the table top where they are given attention and made ready to be placed into clean or new tanks. While the elements are being attended to the tanks are moved around the end of the table where the sediment is removed with water projected at 120 pounds pressure through a number of small holes in a lead form after which they are dried with steam and air, bottoms oiled, rollers or skids renewed. These operations bring the tank in position to receive the elements without further movement. With this table the attendants maintain an erect position during all operations except when raising or lowering elements.

All drainage is carried away in vitrified ducts and where essential the mud is separated from the drainage before leaving the table and finally in the catch basin before entering the sewer.

Miscellaneous Equipment.

Further completments are a lead burning outfit, a Rochlitz still and a steam cooker for heating the compounds used in floating the linings into tanks or sealing the covers. This cooker is built of boiler steel in such manner that the containing vessel is surrounded by a steam-tight jacket provided with the necessary traps, valves and standards. It is possible to regulate the temperature of the compound to the degree best suited to the operation at hand. Sufficient compound is contained to float more than one set of eight double compartment tanks or to seal an unlimited number of covers as the compound is readily melted when added in not too large quantities.

Three tubs are located convenient to the battery table, in which the connectors and covers are cleaned in hot and cold water.

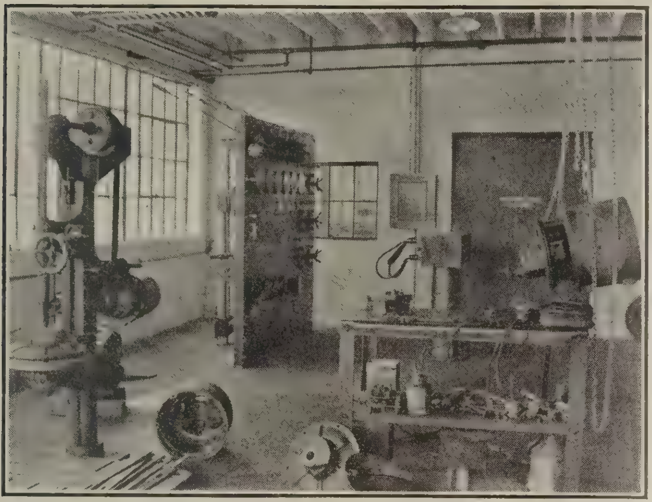


Fig. 2. Showing Switchboard and Generator Repair Equipment. Note the Plugging-in Box on Post in the Background.

Battery Charging Facilities.

Battery charging benches are located as shown by the photograph taken from the middle of the battery room. These are furnished with charging receptacles the circuits of which are so arranged that it is not necessary to carry the charging cables across the floor, should it be desired to place batteries on separate benches in series. Twenty 32-volt sets may be charged at one time should it be desired.

In the adjoining room is located the switchboard also the benches and other requirements necessary to the repair of generators, regulators or other electrical apparatus a part of the car equipment. Machinery is being installed to make possible the trueing of commutators, facing of pulleys or the machining of many different parts incident to repairs of this character.

Switchboard.

The switchboard is served with direct current from the local power house at 220-110 volts through the medium of two cables, lead-sheathed and of three conductors each pulled into separate fiber conduits; these are laid in concrete and drain into the several manholes. The use of duplicate service is protection in case of a breakdown in one or other of the cables.

Current enters through a triple pole, 300-ampere circuit breaker and is distributed through the bus bars to six single pole double throw switches selecting either the 110-volt or 220-volt bus for its respective rheostat. These are of the Allan Bradley carbon pile type and consist of four tubes each, the circuit in connection being protected by an overload reverse current circuitbreaker. Balancing the load is taken care

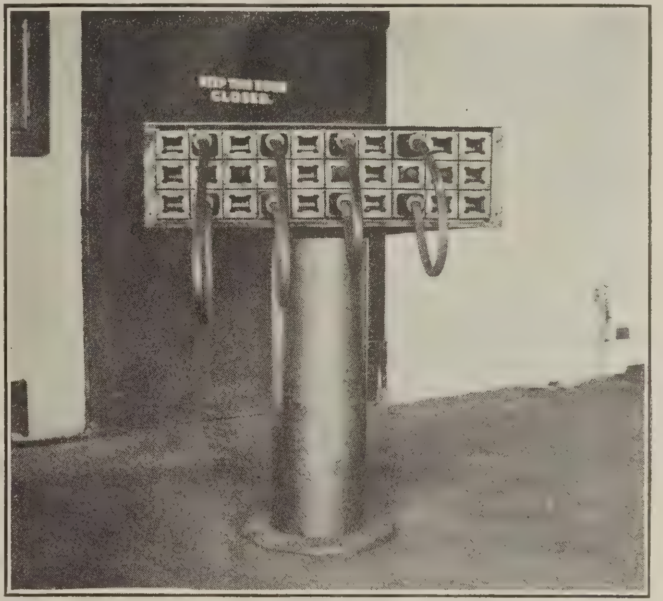


Fig. 4. Plugging-in Box for Making Connections to Battery House and Yard Circuits as Desired.

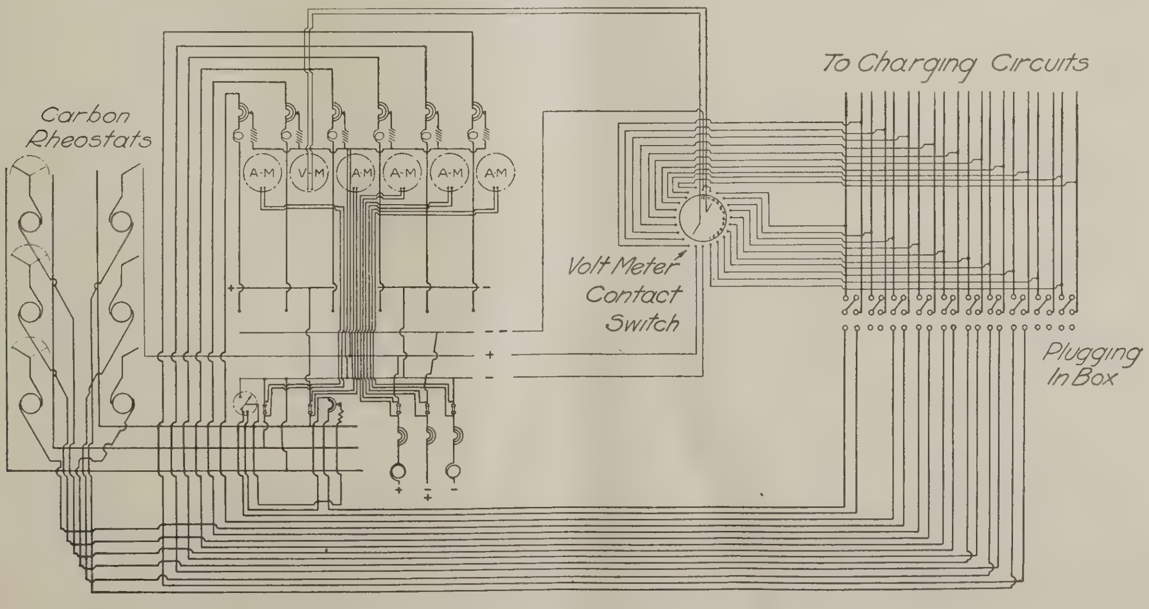


Fig. 3. Wiring Diagram of Switchboard and Charging Connections.

of through the arrangement of the rheostat circuits, three on the positive and three on the negative sides, as may be seen by referring to the diagrams. A zero center ammeter shunt is put in circuit with the neutral bus and serves to indicate which side of the circuit to employ when additional charging circuits are to be used.

The amount of current flowing in any of the rheostat circuits is indicated by ammeters, the shunts of which are cut into or out of circuits by single pole double throw switches mounted close to the rheostat handles on the switchboard.

Ten charging circuits, six rheostat circuits, a generator test circuit, a bank of lamps, a forty-volt motor circuit and a circuit in connection with a single pole circuit breaker actuated by the contact of an amperehour meter, enter into a large receptacle which for want of a better descriptive name has been referred to as a "plugging-in box." This contains three tiers of ten charging receptacles each in which six of the bottom tier are in connection with both terminals of the rheostat circuits and the remaining four in the test, lamp, motor and ampere hour meter circuits. The center and top tiers of receptacles are arranged in vertical pairs in series, in which terminate the charging circuits serving the car shops, storage tracks, coach yard and battery house benches. This arrangement permits of plugging in any number of circuits in series with any one of the six rheostats by using a flexible two-conductor connector between the receptacles. It further provides for the discharge or charge of a battery to any number of amperehours desired through the medium of the amperehour meter and circuitbreaker.

This departure in arranging circuits in so compact space has proven very satisfactory, being adaptable to and permitting numerous combinations in the connection of battery charging lines, so obvious upon reference to the wiring diagram that to enumerate would be uncalled for.

A. R. E. E. Semi-Annual Convention

Reports of the Committees

Meeting to be called 9:30 A. M., June 12th, at the Hotel Dennis, Atlantic City.

Order of Business.

1. Minutes of Last Meeting.
2. Address of President.
3. Report of Secretary-Treasurer.
4. Unfinished Business.
5. New Business.
6. Reports of Standing Committees.
7. Report of Special Committee.
8. Paper on "The Ampere Hour Meter in Car Lighting Service.
9. Miscellaneous Business.

Adjournment.

The final report of the Day Coach Lighting Tests, conducted last summer by the illuminating committee, A. R. E. E., L. S. & M. S. Ry., and other railroad and manufacturing interests will be presented at the convention. This report includes the detail data of 64 of the tests, as well as general summary, conclusions, etc., together with committee report. Copies may be obtained from Secretary Andreucetti, price $1.00.

Committee on Axle Equipment

Your committee is instructed to "report the development in axle equipments, and the general tendency of railroads toward axle lighting in preference to other systems."

Inquiries have been sent to nearly all railroads owning 100 passenger cars or over, about 80 in all. This foı the purpose of ascertaining the general attitude toward axle equipment,

While it is just as much within the province of the committee on Head End Equipment to report on storage batteries as it is ours, we will report on that subject, and the information submitted may remain a part of our report, or otherwise, as may be elected by the executive committee.

Personally, I should like to see the published proceedings edited in any way that would consolidate information pertaining to the same subject, regardless of the committee which presents it.

There was very little information submitted to the 1913 convention on the subject of axle equipment *development*. "Battery charging" covered the various principles of operation. "Standards" dealt largely with this equipment. In 1912 the committee on "Improvements" reported on axle equipments in addition to the wealth of other information given. I rather like the plan of that committee and propose in the same manner to submit a section referring to each axle equipment and storage battery by name.

Another possible conflict between the report of the head end committee and ours is the question of the axle dynamo used for serving an entire train. That apparatus was reported by the committee on Head End Equipment in 1913, but I believe properly should be included in the report of the committee on axle equipment this year. We therefore propose to cover it in our report.

In order to give sufficient time to get the report in shape, it is our purpose to cover the period to July 1st, 1914.

We are in communication with all storage battery companies, and plans have been made and work divided among the committee members so that we expect to submit as complete a report on the subject assigned to us as we are capable of preparing.

We wish to invite suggestions from any members in attendance at the semi-annual convention, as to the activities of our committee or receive any criticism of our outline.

Respectfully submitted,

H. R. Bucks, Chairman.
Ch. Elec. Oregon Short Line.
Geo. W. Murrey,
Chief Elec. S. P. L. A. & S. L. Ry.
E. M. Cutting,
Edison Storage Battery Co.
N. E. Lemmon,
Elec. Eng., Pullman Co.

Committee on Axle Belting

Your committee is pleased to submit herewith a copy of the Specifications for Belting for the purpose of driving axle generators, the same having been agreed upon by the Committee and which is submitted as the Committee's report.

A., B. & C. RAILWAY COMPANY.

Specifications for Belting for Axle Generators.

Ordering. 1. All belting for axle generators used by the A., B. & C. Railroad, Ordering or by Contractors building Railroad Company equipment, shall be purchased in accordance with the requirements of these specifications, and shall be ordered in rolls of approximately 500 feet, as the demands of the service indicate. The kind, width and number of plies of belting desired shall be specified on the order. Stitched or woven belting shall be subject to all the requirements of these specifications except the friction test.

Stitched canvas, rubber or woven belting may be ordered.

Material Desired. 2. All rubber belting shall have not less than four plies of friction duck and shall have a rubber cover 1-32 inch thick, of such quality and cure as to resist wear on the pulleys; the cover to be so firmly attached to the duck that it cannot be separated without tearing the rubber. Stitched or woven belting shall be impregnated with a waterproof composition.

Badge Plate. 3. A badge plate shall be placed at every nine feet on the belting. On rubber belting this plate shall be of rubber vulcanized fast to the cover, and on stitched or woven and balata belting it may be a stencil. The badge plate shall bear the manufacturer's name or trade mark, date of manufacture, and a serial number which should commence with "one" at the beginning of each year and continue consecutively. The serial number shall be the same on each roll of 500 feet or fraction thereof.

Sampling. 4. When belting is received at the Store House, it shall be examined to see that it is in accordance with the order and has the required badge plates properly spaced. A sample three feet long shall be cut from any part of a whole or fractional roll and forwarded to the Engineer of Tests, with a "Sample for Test" tag, giving the following information:

Number of feet represented by the sample.
Serial number.
Name of manufacturer.
Name of consignee.
Order and requisition numbers.

Tests. 5. Friction Test: (Does not apply to stitched or woven belting.) A section six inches in length shall be cut from the sample, and from this, a strip one inch in width shall be cut on the longitudinal axis of the belting. The friction shall be determined from this specimen, by weighing the pull necessary to start the unwinding of the duck. The test shall be made in a tensile test machine at a speed of 20 inches per minute. The pull in pounds necessary to start the separation of the duck shall be taken at three different points, and the average of these three readings shall be considered as the friction.

Stretching Test: Marks 18 inches apart shall be placed on the remaining 30 inch length of sample, using the full width of the belting, and it shall be pulled in a tensile machine with a slowly applied load in pounds equivalent to the product of the number of plies of duck, times the width of belting in inches, times 200. The load shall be maintained a sufficient length of time to allow measuring the stretch between the 18 inch marks.

Rejection Limits. 6. A roll of belting, as represented by the serial number, will be rejected if:

a—The width varies more than 3-16 inch either way from that specified on the order.
b—When examined by the Storekeeper it is found not to be straight or has any injurious defects.
c—It does not bear the required badge plates correctly spaced throughout its length.
d—The friction is less than 18 pounds.
e—The stretch in 18 inches exceeds two inches.
f—The belting breaks under the stretching load.

Claim for Rehearing. 7. Samples of rejected belting will be held one month from date of test report. In case the manufacturer is dissatisfied with results of test, he may make claim for a rehearing within that time. Failure to raise a question within one month will be construed as evidence of satisfaction with results of test, the samples will be scrapped, and claim for a rehearing will not be considered.

Freight Charges. 8. All rejected belting will be returned to the manufacturer, who shall pay freight charges both ways.

Respectfully submitted,
J. R. Sloan, Chairman, Engr. Elec. Tr. Ltg., Penna, R. R.
Jno. M. Craig, Supr. Elec. Tr. Ltg., Penna. R. R.
J. P. Puette, Ass't Chief Elect., L. S. & M. S. Ry.

Special Committee on Lamps

Following is a record of action taken by the special committee of the A. R. E. E. to consider standardization of train lighting lamps at the meeting held at La Salle Hotel, Monday, May 18th.

Train lighting lamps were divided into two general classes; first, lamps to be recommended for adoption as standard for train lighting service; second, lamps accepted for train lighting service but the use of which is not recommended.

Lamps for Recommended Practice.

Voltage Range	Nominal Watts	Mean Horizontal Candle-power	Type of Bulb
25 to 34	15	12	G-18½
and	25	20	G-18½
50 to 65	50	40	G-30

Train Lighting Lamps Accepted But Not Recommended.

Voltage Range	Nominal Watts	Mean Horizontal Candle-power	Type of Bulb
25 to 34	15	12	S-17
and	25	20	S-19
50 to 65	75	60	G-30

It is the understanding that the lamp companies will have prepared tentative schedule covering these lamps which will include actual watts, total lumens, efficiencies, etc., and, if possible, to have this ready for the mid-year convention to be held at Atlantic City, June 12th.

Respectfully submitted,
L. S. BILLAU, Chairman.

Committee on Wire and Cable Specifications

Your committee is pleased to submit the following progress report:

(1) This committee has requested the secretary of the association to send copies of Vol. 6 of the Proceedings, to a selected list of manufacturers and others interested in wires and cables. The committee is endeavoring to obtain criticisms from them and to obtain the benefit of experience with the 1913 specifications.

(2) The committee has conferred with the corresponding committee of the American Electric Railway (Engineering) Association, with the object of securing uniform standards for the two associations. This shows every promise of being accomplished.

(3) The chairman of this committee was a member of the Wire and Cable Subcommittee of the A. I. E. E. Standards Subcommittee, and is taking advantage of the work of the latter committee to keep our specifications up to date.

It is proposed that when the A. I. E. E. Standardization Rules are adopted the association specifications can be considerably shortened by referring to the Institute's standard clauses.

(4) Your committee is keeping in touch with the Joint Rubber Insulation Committee and will incorporate whatever changes that may be necessary in the rubber specification on account of the continued activity of that committee. It is expected that the report of this committee will make no important change in the 1913 specifications, which are likely to be good in substantially their present form for several years. The work of the committee is more in the nature of keeping in touch with up-to-date work and keeping in line with the standardization being effected by other associations.

Respectfully submitted,
Wm. A. Del Mar, Chairman,
Asst. Engr. N. Y. C. & H. R. R. R.
Major Azel Ames,
Kerite Insulated Wire & Cable Co
W. S. Clark,
General Electric Co.
A. L. Crater,
N. Y. C. & H. R. R. R.
R. W. Krass,
New York Edison Co.
W. L. Middleton,
Simplex Wire & Cable Co.
F. J. White, Okonite Co.

The Ampere Hour Meter in Car Lighting Service

Paper to be Read Before A. R. E. E. Semi-Annual Convention, June 12, by Edward Wray

There are several types of ampere hour meters designed to meet various conditions of storage battery service. For straight storage car lighting, the simple shunt, differential shunt or resistor type meter can be used; head end service, duplex or register type meters; axle generator system, variable resistor type meter is best adapted.

Resistor type meter recently applied to and now operating successful on over 100 *axle equipments. Battery charge is controlled on an ampere hour basis by the meter, which automatically provides charge of 20% more than discharge, measured in ampere hours.*

Although ampere hour meters have been used for a great many years in laboratory experiments with storage batteries these meters were never considered sufficiently reliable for practical service until the advent of the mercury type ampere hour meter in 1908. There have been numerous modifications and improvements made since the first mercury type meter was constructed, so that at the present time we have an ampere hour meter designed to meet the special requirements of almost every type of storage battery service.

Before going into the various modifications of the ampere hour meters designed for car lighting service, however, we will consider the general principles underlying the operation of this meter.

The Principles of the Ampere Hour Meter.

As its name would indicate, this meter records simply ampere hours and has no reference whatever to the voltage of the circuit. An ampere hour means a current of one ampere flowing for one hour, of two amperes for ½ hour, etc. Forty amperes for ½ hour would be 20 ampere hours and this would be so recorded by an ampere hour meter in circuit.

It is a well-known principle that any wire carrying a current, and at the same time located in a magnetic field, will tend to move out of that field in a direction perpendicular to both the lines of force and the conductor. This is the principle upon which all direct current motors operate.

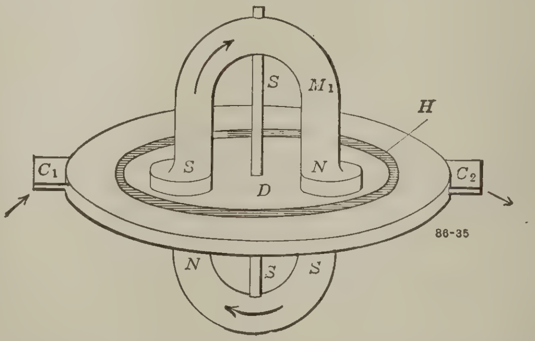


Fig. 1. The Elements of the Mercury Meter. Current Enters C-1 and Passes Mercury H to Rotating Disc D, Through Disc, Under Both Magnet Poles, Through Mercury H to C-2.

The mercury motor ampere hour meter, like all other meters, consists simply of a motor generator set coupled to a revolution recording mechanism; the speed of the set is proportional to the number of amperes current flowing through the meter disc.

The mercury motor consists essentially of a copper disc floated in mercury between the poles of a permanent magnet and provided with leads to and from the mercury at diametrically opposite points. The theoretical relations of the various parts are shown in Fig. 1. The current of electricity, carried by the circuit in which the ampere hours are to be measured, enters the contact C-1, passes through the comparatively high resistance mercury H to the edge of the low resistance copper disc D, across through the disc to the mercury H and out of contact C.

The magnetic field of the motor is produced by the permanent magnet M-1 and, as this is constant at all times, regardless of battery voltage, the speed of the meter will be simply proportional to the number of amperes flowing and ampere hours will be recorded. The difference between this and the watthour meter is that the magnetic field of the watt meter is produced by a winding of fine wire connected across the terminals of the circuit. That magnetic field is then proportional to the voltage, and the meter records total power, the product of the volts times amperes, or watts. The relative direction of the magnet flux and current of electricity, as well as the resulting motion of the copper disc in the ampere hour meter are shown in Fig. 2; a reversal of direction of current flow will cause a reversal in direction of rotation.

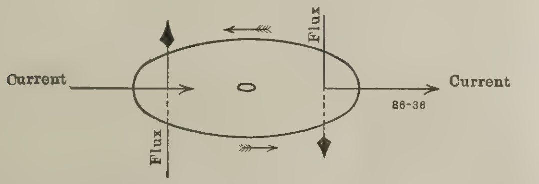


Fig. 2. Showing Relation of Magnetic Flux, Current and Direction of Rotation of the Meter Disc.

The aluminum disc, or eddy-current damper, rotating between the poles of permanent magnets at the top of the meter, Fig. 5, represents the generator part of the set since it takes power to drive it. This power is directly proportional to the speed of rotation, therefore, the speed at which the meter rotates is then a direct measure of the rate of current flow through the meter; 100 revolutions of the motor corresponding to one ampere hour. A recording gear train is driven from a worm gear on the shaft which records the revolutions and indicates the total number of ampere hours having passed through the meter. The construction of the meter is clearly shown in the diagram Figs. 5 and 6, but it should be noted that these diagrams show the resistor element which is attached to the bottom of the magnet poles of the meter. This feature, of course, is omitted in other types.

It should be noted that the mercury cannot spill out of the chamber, whatever be the position of the meter. The mercury completely covers the disc and the wooden float in the center of the disc is so proportioned that the upward buoying effect of the mercury just balances the weight of the entire rotating element, in fact, delivers a slight upward thrust of about $\frac{1}{10}$ of an ounce. There is then practically no weight on the jeweled bearings, and as the mercury has a cushioning action, the meter is in no way affected by the severe vibration as found on railway cars.

The magnetism of the permanent magnet flows from the north pole (N) upward into the iron ring shown in section of the diagram, and thence through the iron ring to the opposite side, where it flows into the south pole (S). In passing to and from the iron ring, however, this magnetism cuts through the copper disc carrying the electric current, on the right hand side of the magnetism is in an upward direction and on the left hand side in a downward direction. The resultant forces between this magnetism and the electric current, cause the motor disc to rotate as shown.

There are various types of ampere hour meters designed to meet the special requirements of certain classes of service.

Straight Storage System.

The first mercury ampere hour meter built was a simple shunt type without any auxiliary contacts or other automatic features whatever; it simply recorded true ampere hours, the dial hand revolving slowly in one direction on discharge, and in the reverse direction on charge. So in order to make the meter act automatically in cutting off at the end of charge, a reset device and zero contact was added so that when the battery was placed on charge the meter hand could be manually set ahead 10 to 25% (as desired) of the number of ampere hours previously discharged and when the hand got back to zero a charge of 10% to 25% more than the previous discharge would have been given the battery; the zero contact would then operate a circuit breaker and stop further charge. This

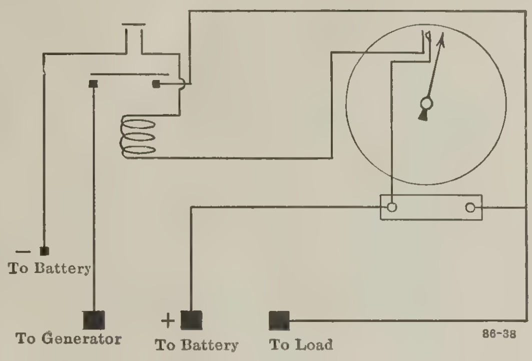


Fig. 3. Simple Shunt Meter with Contact to Circuit Breaker for Stopping Charge in Straight Storage Service.

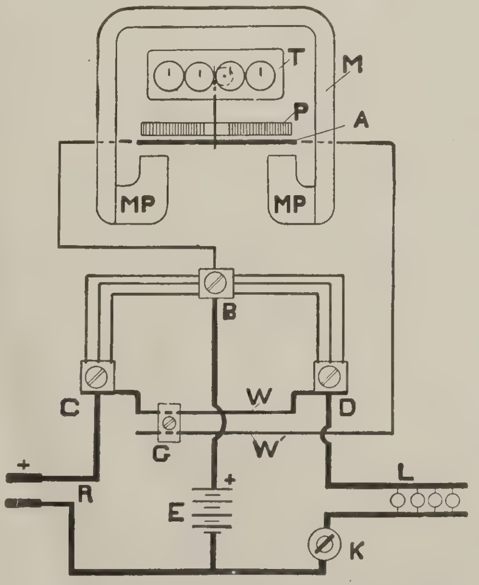


Fig. 4. Differential Shunt Type Meter for Automatically Providing Suitable Charge in Excess of Discharge in Straight Storage Service.

circuit is shown by diagram Fig. 3. Several roads still use this type of meter in their straight storage service.

In order to make the meter operate still more automatically, a differential shunt device was added to make the meter automatically run 10% to 25% (as desired) slower on charge than on discharge and this would take care of battery losses in the same manner as manually setting the meter ahead 10% or 20%, as mentioned above. The meter then indicates at all times the amount of capacity actually in the battery. Wiring diagram of the circuit is shown in Fig. 4.

It should be noted, however, that this meter will not operate satisfactorily on any circuit where lights are on while the battery is being charged, such as experienced in axle generator service. In other words, in order to get true ampere hour indications with the differential shunt type meter all lamps must be turned off when the battery is on charge.

Head End System.

The duplex train meter has been used somewhat in this service, but only for giving a check indication on the amount of charge and discharge which the battery receives. The meter contains a double gear train with double set of dials, one set operating only on discharge and the other on charge. The meter will then simply record total charge and total discharge which the battery is receiving, but by taking these readings at the end of every day's run the official, to whom these reports are turned in, can easily tell how each battery under his supervision is being handled, and note whether it is being given enough or too much charge; instructions can then be issued accordingly.

A certain amount of discretion must be shown in making use of these daily ampere hour readings of charge and discharge, and it should be fully understood that only an occasional reading of the meter means a little or nothing. For instance, a certain battery which came to the attention of the author was badly in need of charge, although the duplex train meter showed a charge reading considerably in excess of the discharge reading. Without stopping to analyze the situation a person might think that the ampere hour meter was inaccurate and unreliable. Upon referring to the daily meter readings, however, it was found that this meter had been given a very heavy overcharge on the first run and had been under-charged on all succeeding runs. The point is that this overcharge came all at one time instead of being distributed over all the charges as it should have been.

A circuit has recently been devised by the author which makes it possible to use the resistor type meter for controlling the operation of storage batteries in head end service. It is obvious that the storage battery must be available for service instantly whenever the steam driven unit is shut down or the train line opened, so any of the standard cutout meter devices employed in straight storage or axle generator service cannot be made use of in this class of service. A resistance which is normally short circuited by a circuit breaker is placed in series with the battery, as shown in diagram Fig. 5. The winding of a small polar relay is also placed in series with this resistance and also short-circuited by the circuit breaker.

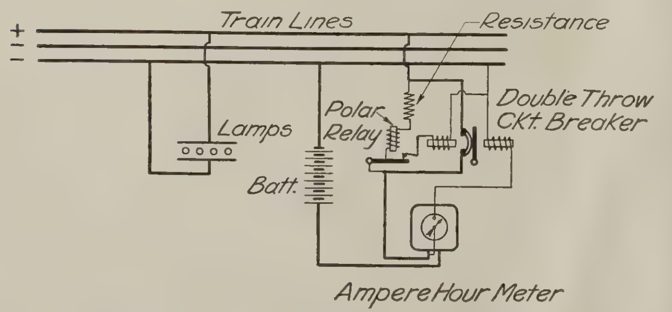


Fig. 5. Design of Circuit for Employing Resistor Type Meter to Control Charge Given Battery in Headend Service.

When the battery is fully charged and hand of the ampere hour meter gets back to zero, contact will be made in the meter which will operate the double pole circuit breaker, causing it to open. This will insert the above-mentioned resistance in the battery circuit and practically stop further charging. As soon as the train line of voltage falls a few volts below the battery voltage, however, current flowing through the winding of the polar relay will close the circuit, which will energize the restoring coil of the main circuit breaker and cause it to close again and connect the battery directly to the line. To the best of our knowledge, this idea has never been employed before, but any railroad company is welcome to make use of the idea in any way it sees fit.

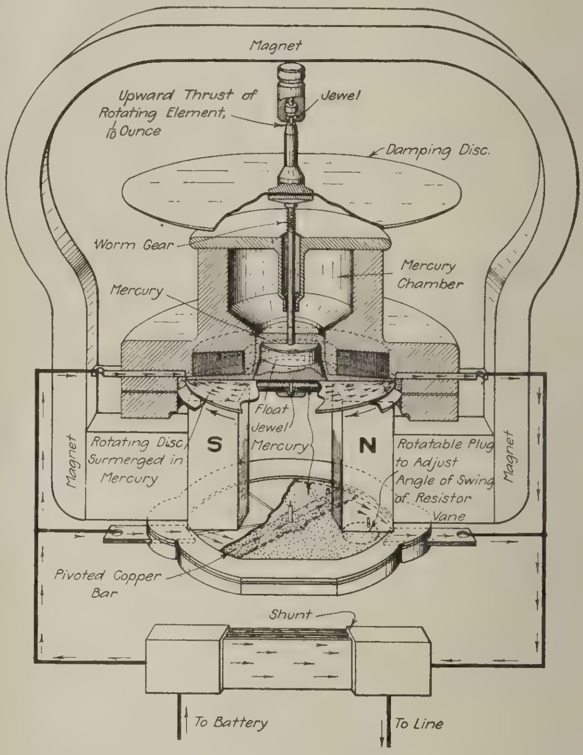

Magnet
Upward Thrust of Rotating Element, 1/10 Ounce
Jewel
Damping Disc.
Worm Gear
Mercury
Mercury Chamber
Float
Jewel
Mercury
S
N
Magnet
Rotating Disc Surmerged in Mercury
Rotatable Plug to Adjust Angle of Swing of Resistor Vane
Magnet
Pivoted Copper Bar
Shunt
To Battery
To Line

Fig. 6. Showing the Direction of Current Flow and Meter Rotation with Battery on Discharge. Small Arrows Indicate Direction of Current Flow and Larger Arrows Indicate Direction of Rotation of the Meter Disc.

Axle Generator System.

A special meter has been developed for axle generator service known as the resistor type ampere hour meter, which measures both charge and discharge of the battery and provides that the meter runs 10% to 25%, (as desired) slower on charge than on discharge. A zero contact (A) for stopping further charge is provided and also a restoring contact (B) as shown in Fig. 10, to restore normal operating conditions after the battery has discharged a few ampere hours. This meter was fully described in the *Railway Electrical Engineer,* March, 1914.

It is well known that any storage battery must be given a greater number of ampere hours charge than it is capable of delivering on discharge, the excess depending upon the ampere hour efficiency of the battery.

This battery efficiency, however, is not a definite factor, as might be considered on first thought, but depends on many variable factors, such as amount of current, temperature, condition of plates, but chiefly upon the interval of time between complete charges and complete discharges, or their equivalent in ampere hours.

For instance, in central station stand-by battery service, batteries may stand in a fully charged condition for months without any discharge and still require occasional charging to keep them up to full capacity. The ampere hour efficiency in this case would be zero. The other extreme is in floating battery service, where we find frequent surges of current in and out of the battery, often making several cycles of charge and discharge in a single minute. Here the ampere hour efficiency would be extremely high.

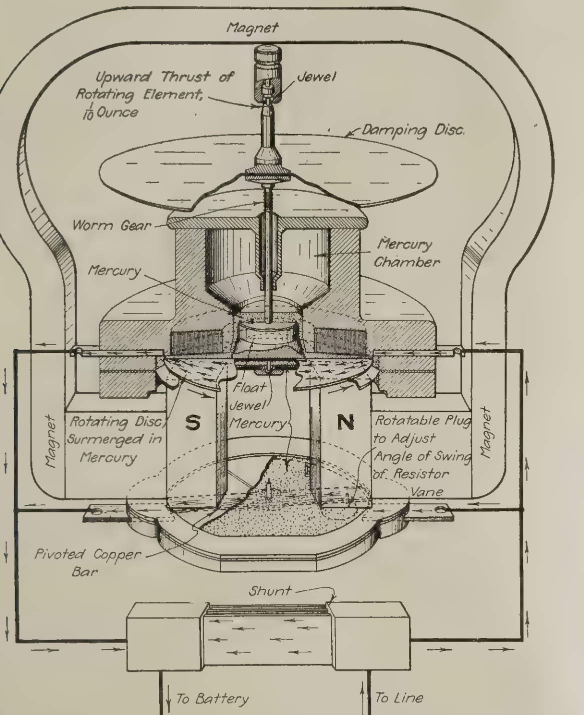

Magnet
Upward Thrust of Rotating Element, $\frac{1}{10}$ Ounce
Jewel
Damping Disc.
Worm Gear
Mercury Chamber
Mercury
Float
Jewel
Mercury
S
N
Rotating Disc, Surmerged in Mercury
Rotatable Plug to Adjust Angle of Swing of Resistor Vane
Magnet
Magnet
Pivoted Copper Bar
Shunt
To Battery
To Line

Fig. 7. Direction of Current Flow Through Meter on Charge. Note That the Resistor Bar Has Moved Through a Slight Angle and Is Now Almost in Line with the Contacts. This Increases the Current Through the Resistor and Decreases the Current Through the Meter Disc, Causing It to Run Slower on Charge.

In axle car lighting service we will find conditions somewhere between these two extremes. The actual percentage efficiency, however, is not easy to determine, in fact, will at best be a compromise, for conditions of axle generator service vary widely. In the majority of cases where axle devices have been equipped with ampere hour meters for automatically controlling the charge on a percentage overcharge basis, the meter has been set to provide an overcharge of 20% more than the previous discharge in ampere hours.

Method of Applying Meter to Axle Generator Systems.

There are several different methods of employing the ampere hour meter to control the operation of various axle generator systems, depending largely upon the characteristics of these systems: (1) For constant current regulators of the quick regulating type, such as all carbon pile regulators, the Frost-Everett, the Newbold, type "L" Consolidated, etc., the ampere hour meter relay could simply open the field circuit and restore same when a discharge of 15 ampere hours has been taken from the battery; (2) In all combination current-voltage regulating devices, such as the Gould, Safety, U. S. L., etc., the best practice is probably to have the meter short-circuit a resistance in series with the potential regulating coil when the battery becomes charged. In this way the fully charged battery can be floated at any potential desired.

In practically all the 100 equipments so operated, at the present time, the ampere hour meter, instead of opening the generator circuit when the battery becomes fully charged, simply reduces the generator voltage to a floating value of 35, 36 or 37 volts as desired. The meter may indicate a full charge and the relay operate, yet the generator may continue to give the battery a soaking charge at a very low current rate if the battery was not fully charged when the meter indicated that condition. Then even assuming that the ampere hour efficiency had not been set quite high enough, this soaking charge would bring the battery up to full capacity, provided the run is long enough.

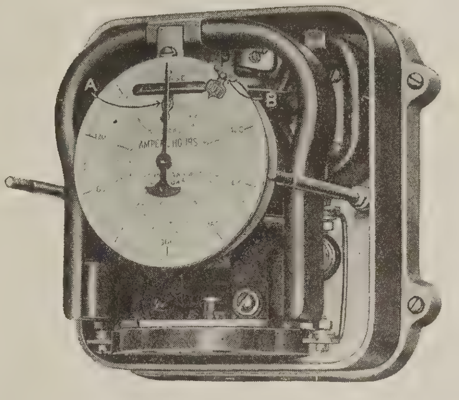


Fig. 9. The Variable Resistor Type Ampere Hour Meter with Case Removed. Contact "A" Stops Further Charging and Contact "B" After a Slight Discharge, Restores Normal Operation of the Equipment.

Some Test Results.

Some very interesting tests have been run on axle lighted cars equipped with a graphic recording ampere hour meter as well as the controlling ampere hour meter with potential regulation as above mentioned. In other words, the controlling ampere hour meter controls the operation of the generator on an ampere hour basis and the recording ampere hour meter at all times indicates amount of charge in the battery, but when the battery was being charged normally and after it had reached the full charge point and was being given the floating charge, as above mentioned.

This graphic meter consists of an ordinary variable resistor type ampere hour meter with special gear train attachment. This latter transfers the circular motion of the indicating meter hand to a straight line motion of the recording pencil. An operating clock draws the paper tape slowly under this recording pencil and a record of ampere hour capacity in the battery at all times is thus made.

These tests were all run with both controlling and recording meters adjusted for 20% overcharge and the floating voltage was set at the various potentials of 37, 36, 35 and 34 volts in different tests on the same equipment.

While only a comparatively few tests have been made a sufficient amount of data has been obtained to indicate that within a few months some valuable information will be available relative to the much mooted question of proper floating voltages, battery efficiencies, rate of charge, and later their effect on battery plate life.

School of Electricity

A Course of Training Prepared by the Pennsylvania Railroad for Its Employees

All back lessons of this course will be furnished at 5 cents each, which will also include, (1) Railroad Electricians' Club, (2) A B C Car Lighting Course, (3) Practical Stunts, and (4) Question Box, as published that particular month.

Lesson No. 13--Curve Reading

A great many reports on the operation of electrical and mechanical apparatus, comparisons between different makes of the same type of equipment, and much tabulated inofrmation is often shown by means of curves. These "curves" may be straight lines, but they show the relations between the different elements or variables considered. A great many conditions involving these variables may be much better understood if one is able to read and understand these curves and also to plot them as well.

The method of plotting, or locating, thhe points through which the curves are drawn, will be readily understood by following out the scheme shown in Plate 1, which shows the points used for drawing the curves in Plate 2. These two curves are obtained from table of Allowable Currents which can be carried on wire with "Rubber Insulation" or "Other Insulation," as published in Lesson No. 1. This table is repeated herewith.

Table No. 1.—Allowable Currents in Insulated Wire

B. & S. Gauge.	Circular Mills.	Rubber Insulation Amperes.	Other Insulation Amperes.
18	1,624	3	5
16	2,583	6	8
14	4,107	12	16
12	6,530	17	23
10	10,380	24	32
8	16,510	33	46
6	26,250	46	65
5	33,100	54	77
4	41,740	65	92
3	52,630	76	110
2	66,370	90	131
1	83,690	107	156
0	105,500	127	185
00	133,100	150	220
000	167,800	177	262
0000	211,600	210	312

In all the plates, the vertical column on the left side is called the *ordinate* and the horizontal at the bottom, the *abscissa* (pronounced as if spelled absissa). In Plate 1, the ordinates are for amperes and the abscissa represents the B. & S. Gauge.

By looking at one of the plates it will be seen that there are 10 large divisions across the short way of the paper and 15 the long way and that each of these divisions is divided into 10 small divisions.

By referring to the table above mentioned, it is seen that there are 16 different sizes, ranging from 4/0 or 0000 to 18, and that the current values vary from 3 amperes for "Rubber Insulation" to 312 amperes for "Other Insulation," the current for "Other Insulation" having the higher value.

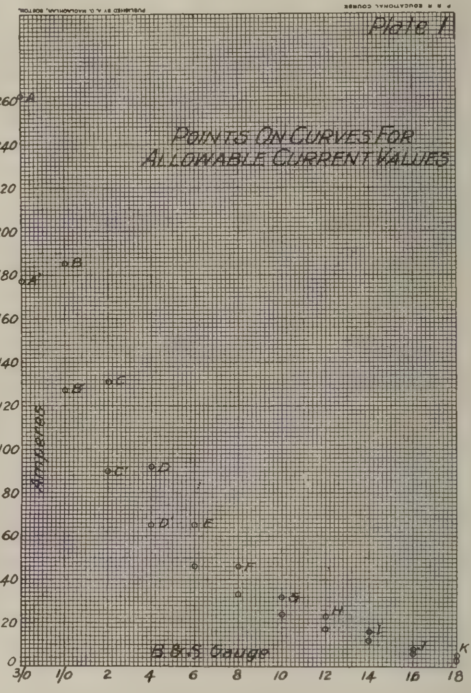


Plate 1. Values Given in Table 1 Plotted as Points A, B, C, Etc.

It was found that the curves could be plotted to a scale that would be more readily understood if 4/0 was omitted, so that the quantities represented include only 3/0 to 18. This would leave 262 for 3/0 as the highest figure to be represented.

The first important thing to do is to select the proper scales so that the *curves* will come within the limits of the sheet. It will be seen that if 20 amperes per large division is used for the ordinate, then 262 amperes would come within the sheet and if two sizes of the B. & S. Gauge per large division are taken for the abscissa, then the scale from 3/0 to 18 will just come within the 10 divisions for the other scale. These scales would make each of the small divisions along the column on the left, or ordinate, equal to 2 amperes, and five of the small divisions along the base line, or abscissa, equal to one size or gauge.

Points, such as A, B, C, D, E, F, G, H, I, J and K on Plate 1 are determined by taking the current value for 3/0, 1/0, 2, 4, 6, 8, 10, 12, 14, 16 and 18 gauge, respectively. For instance, to find the point C, which is for No. 2, it is seen from the table that 131 amperes are allowable for "Other Insulation," then following up from No. 2 to the ordinate corresponding to 131, which would be five and one-half divisions above the line corresponding to 120, point C is located; for 3/0 it is 262 as shown at A; for No. 8 it is 46 as shown at F, and so on, using the current values shown in the column of "Other Insulation" for the different sizes. In the same manner other points than those shown on the curve could be determined, if considered necessary. These points are then all connected by a smooth curve as shown in Plate 2 for "Other Insulation."

Similarly, for the curve for "Rubber Insulation" using

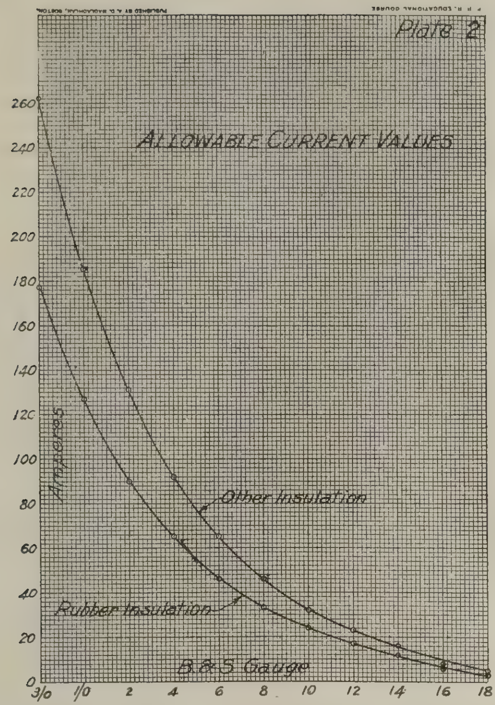


Plate 2. Line Drawn Connecting Points of Plate 1 Gives a Curve from Which Intermediate Values May be Obtained.

the same scales. The next to the highest value shown in table is for 3/0 and is 177 amperes, which corresponds to A′. The current for No. 2 is seen to be 90, which is pointed off on the line for No. 2 at a point corresponding to 90, as shown in the column of ordinates on the left side, and is shown as C′. The remaining points on this curve are obtained in the same way and the curve then drawn through them as in Plate 2. By the method outlined above all the points have been obtained and the curves constructed substantially as shown on Plate 2. By a similar method points can be plotted and curves constructed for almost any tabulated or other data.

A comparison of these curves shows at a glance how the allowable current values for the different classes of insulated wires vary for the different sizes. This variation is most marked in the larger sizes and falls off very fast at first as shown by the very steep curves and gradually runs out where they have nearly the same values.

Take for example the *characteristic curve of a 400 Ampere Hour Primary Cell* as shown in Plate 3. This shows graphically the hehavior of the cell during the entire period of the discharge, that is, from the time the circuit was closed just after the cell was assembled until it has been discharged below 0.3 volt. The curve is for a continuous discharge of 0.5 ampere, so that for each day there will be 12 ampere hours drawn from or supplied by the cell. The vertical column on the left shows the voltage across the terminals of the cell. This scale varies from 0 to 1 volt. The horizontal values vary from 0 to 450 ampere hours.

From the curve one can read directly what the voltage of the cell was at any period of its life. For instance, after five days' discharge, there would have been 60 ampere hours supplied by the cell, and reading on the line above 60 to a point where this intersects the curve and then following straight to the left, it will be seen that this gives 0.67+volt. At the beginning of the test, when the cell was first assembled, there was approximately 0.95 volt. The curve shows that this voltage dropped very rapidly after the current began to be drawn from the cell, as it settled down to 0.69 volt after the first 6 ampere hours had been furnished and then fell off very slowly until the cell was exhauted. After 180 ampere hours, or after 15 days, the voltage dropped to 0.64. After 400 ampere hours, or after 33⅓ days, it will be seen, by following the line immediately above the 400 division, that this intersects the curve on the line corresponding to 0.60 volt. After the 425 ampere hour period is passed, which is 25 ampere hours in excess of the rated capacity of the cell, this voltage drops very suddenly again, so that when it passes the 450 ampere hour mark there are but 0.3 volt available at the terminals of the cell.

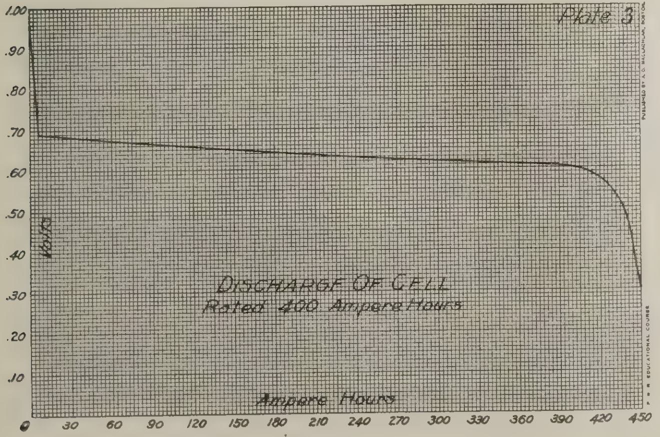


Plate 3. Discharge Curve of Storage Cell.

Curves arranged similar to this can be used to illustrate the behavior of many pieces of apparatus or form comparisons from tests, and they may be much more readily appreciated than by the mere comparison on a data sheet.

The information from which this curve on Plate 3 was plotted was obtained by taking voltmeter readings of the cell at regular intervals from the time it was first assembled until the plates had been entirely exhausted. From these voltmeter readings and the computed values for the ampere hours, points are located

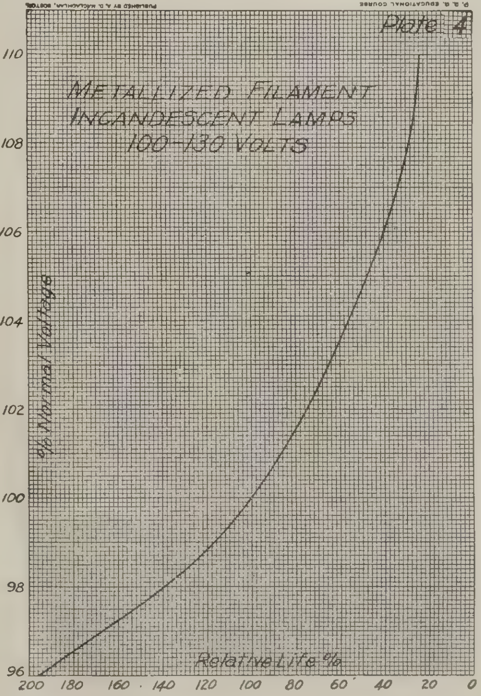


Plate 4. Showing the Variation of Life of Lamps with Varying Voltage.

in the same manner as in Plate 1 and then the smooth curve is drawn through them.

On Plate 4 is an interesting curve, showing the relative life of a *Metallized Filament Incandescent Lamp* when subjected to a higher voltage or to a lower voltage than that for which it was intended. The horizontal values are in relative percentages of the normal life of the lamp, based upon its operation at its rated voltage. The vertical values or ordinates are in the percentages of the regular rated voltages. An example would be the life of a lamp designed for 110 volts and operated on 115 volts. This per cent of the rated normal voltage on which it would be operated would be found by dividing 115 by 110, which would give 1.045 or 104.5 per cent. To find this point on the curve, start from the point on the vertical column midway between 104, and 105, and trace directly to the right until this intersects the curve, then read off directly the per cent of relative length of life on the horizontal line immediately under this point, which gives approximately 51. This shows that approximately one-half of the normal life of the lamp has been sacrificed by operating it on 115 volts. This value, of course, is not true for all incandescent lamps, but the object of this is to show the use of curves and how to read them.

Plate 5 shows an *efficiency curve* of the operation of a 125 light arc dynamo. Here the scale adopted for the horizontal is 50 volts per small division and the vertical scale is 10 per cent per large division. The vertical scale or ordinate also starts at 20 per cent instead of 0 in order to get the curve on the sheet and at the same time use such a scale that it can be readily understood.

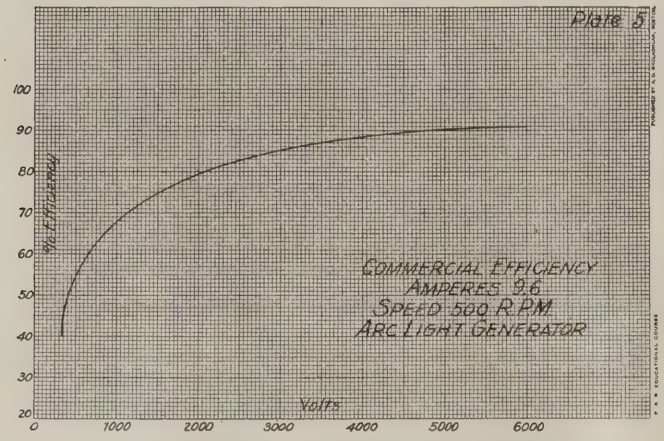


Plate 5. Efficiency Curve of Arc Light Generator.

It will be seen from this that on the low voltage the efficiency is very low. At about 650 volts, the efficiency is shown at approximately 60 per cent. This is found by tracing up directly from the 650 volts point to the intersection with the curve. This intersection is opposite the 60 per cent line, which can be read directly. When 1,000 volts are reached the efficiency increases to about 68 per cent. At 2,000 it is about 79 per cent, while 90 per cent efficiency is not reached until nearly 5,000 volts are generated. After this point is reached the curve is nearly flat or a straight line, showing that about 90 per cent is the highest efficiency which can be obtained on this machine.

By efficiency is meant the ratio of the power output from the generator to the power required to drive it. The curve also shows how very rapidly the efficiency increases at first with slight increases of voltage, and that after a certain point is reached there is practically no change in the efficiency of the machine.

These illustrations will serve to bring out the importance of being able to read intelligently and understand the meaning of curve data, and also how curves can readily be arranged to show accurately the results of any tests or investigations which have variables to be considered. In this respect they would be the same as dials on recording instruments, which are operated by a clock mechanism and which show the variations in the quantities recorded, such as amperes and volts from a generating plant, pounds of steam pressure from a boiler, changes in temperature, or other quantities at any given time and over any given period.

Two interesting curves from a transmission line construction man's standpoint are shown in Plates 6 and 7, which give information regarding the size and weights of chestnut poles and copper wire respectively.

It is obvious that the conditions of the poles, whether freshly cut or well seasoned, would change the weight to a certain extent, but the curves on Plate 6 are based upon the data for seasoned poles as issued by the large lumber organizations.

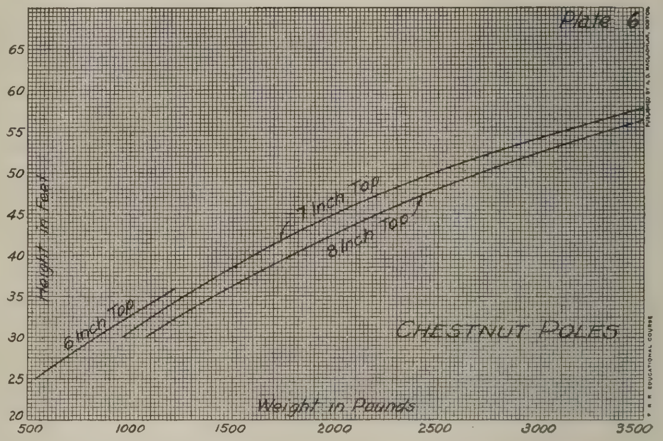


Plate 6. Weight of Various Sizes of Chestnut Poles.

Plate 6 shows the weights of 6 inch poles, 25 to 36 feet long; 7 inch poles, from 30 feet to 58 feet long; and 8 inch poles, from 30 feet to 56 feet long. The scales adopted on this plate may be a little more confusing than those previously studied. For the "Weight in Pounds" on the horizontal scale or abscissa, 200 pounds are represented by one of the large divisions which would mean that a small division would represent 20 pounds, the scale starts at 500 and is marked in 500 pound divisions. On the vertical scale or ordinate, 5 feet are represented by one large division and it starts at 20 feet. From these curves, a 6 inch 30 foot pole is found to weigh 840 pounds, as follows:—From the column on the left, which shows "Height in Feet," trace the line corresponding to 30 to the right until it intersects the curve marked "6 Inch Top." From this point of interesection follow directly down to the base line marked "Weight in Pounds," which will be found to interesect at the 840 pound division. In like manner, 7 inch 30 foot poles are found to weigh 960 pounds; 8 inch 30 foot poles, 1,080 pounds; 7 inch 40 foot poles, 1,600 pounds; and 8 inch 45 foot poles, 2,200 pounds.

From this plate it can be seen what lengths of the different size poles weigh the same. A 30 foot 8 inch pole weighs the same as a 32 foot 7 inch and a 34 foot 6 inch.

In Plate 7 there is shown graphically a *copper wire table* giving the diameters, weights, and safe current carrying capacity of the sizes from No. 9 B. W. G. to No. 14 N. B. S. From curve "A" it will be seen that No. 9 B. & S. has a diameter of 114 mils and weighs about 208 pounds per mile. If it is desired to know what commercial size is nearest to a given diameter, as 130 mils, trace to the right from 130 until it intersects curve "A." It will be seen that this is somewhat larger than No. 8 B. & S., and that a wire of this cross-section would weigh 270 pounds per mile, while No. 8 B. & S. is seen to weigh 263 pounds per mile.

Curve "B" shows the safe current which can be carried by well-blackened line wires of these same sizes.

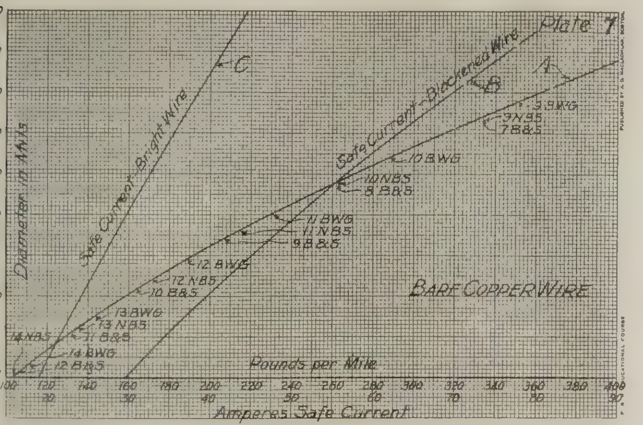


Plate 7. Curves Showing Weights, Diameters and Safe Current for Copper Wire.

The current is found as follows:—For No. 9 N. B. S., trace from the point marked No. 9 N. B. S. on curve "A" directly to the left until it intersects curve "B," then follow directly down to the scale showing "Amperes Safe Current," from which read 65.5 amperes. In like manner trace to the right from No. 10 B. & S. to curve "B" and then read on the lower scale 41 amperes.

In the same manner the safe current for bright wires is read directly by using curves "A" and "C."

The rise in temperature of paneled copper wire; that is, wires in moulding, conduit, or where there is no circulation of air over or around them, is shown in Plate 8, for the different sizes up to approximately 450 mils diameter. A rise of 10° C. above room temperature is considered the limit for safe wiring by the American and Foreign Underwriters' Associations.

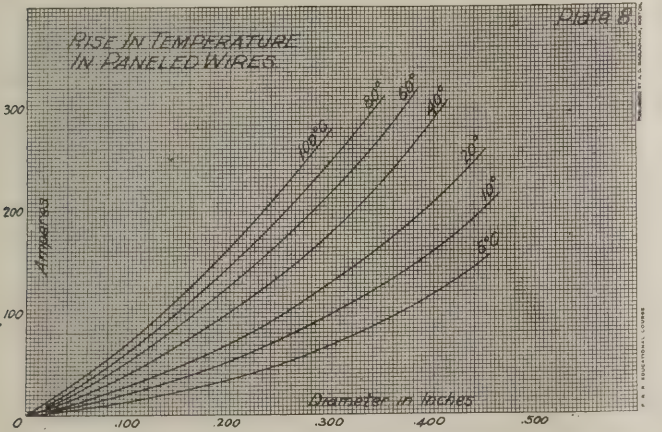


Plate 8. Showing Rise in Temperature of Wire in Molding, Conduit, Etc.

For a wire to carry 52 amperes with a 10° C. increase, it is seen that the diameter of the wire should be .200 inch or 200 mils. The same size can carry 70 amperes with a 20° C. rise, or 100 amperes with a 40° C. rise in temperature.

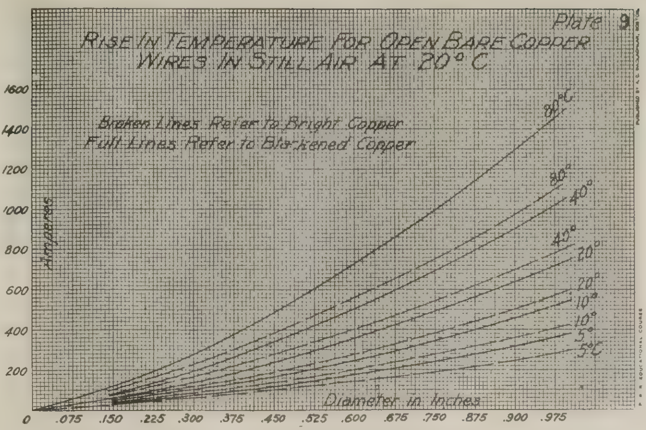


Plate 9. Rise in Temperature of Bare Copper Wire in Still Air.

If it is desired to know the size wire to use in a conduit, when the wire is to carry a given current, it can be read directly for any temperature rise for 5° C. to 100° C. Suppose, for instance, the current was 100 amperes; then for 10° rise the diameter would be .304 inch, or for 20° it is seen to be .256 inch.

Plate 9 shows the difference between bright and blackened copper as conductors of electricity, from a temperature standpoint. It is readily seen that the blackened wire will carry a much larger current than the bright wire for the same rise in temperature. For instance, take a wire .600 inch diameter with a 10° C. rise; trace up from the .600 inch division until the broken line for bright wire marked 10° is reached, then trace directly to the left and read in the column marked "Amperes," 200 amperes, while for the blackened wire represented by the solid line for this temperature it will be seen that 250 amperes would give the same temperature rise. To determine the size of new wire that would carry 100 amperes with a rise of 20° C., follow the line corresponding to 100 amperes, as shown on the left of Plate 9, until it interesects the broken line marked 20°, then read off on the base line the diameter; as, .272 inch or 272 mils.

In Plate 8, the ordinates, "Amperes," are arranged with one small division equal to 4 amperes, and in the abscissa, one small division is equal to .004 inch, while in Plate 9, the ordinates show one small division equal to 20 amperes, and the abscissa .0075 inch.

In all cases, the value of the division is determined by the highest quantity to be shown and the space available on which to show it. The scales should be so chosen that they can be easily understood without having to perform any computations other than mental.

All the curves in this pamphlet were formed by definitely fixing the location of several points on each and then drawing the curved lines through these points. A little practice in plotting curves from the different tabulated data available enables one to more readily understand the meaning of the various curves met and to grasp at a glance the various information it is possible to obtain from such curves.

Problems

First Lesson—Curve Reading

1.—How many more ampere hours than its rated capacity were delivered by the cell in Plate 3, before the voltage fell below 0.6?

2.—What was the output of the cell in ampere hours before the voltage between its terminals fell below 0.65?

3.—If the discharge current was at the rate of 0.5 ampere continuously, what was the voltage of this cell at the end of 10 days from the time it was installed?

4.—This curve was made from readings taken showing the voltage, the current being kept constant at 0.5 ampere. What was this voltage reading after the cell had discharged 25 days?

5.—If a metallized filament lamp is rated at 120 volts and it is operated on a circuit showing a pressure of 125 volts, what will be the length of its life in per cent, compared with that at its normal voltage?

6.—(*a*) If the lamp is to burn 0.8 of its normal life, what can be its maximum per cent of normal voltage?
(*b*) If the operating voltage of the lamp in Problem 5 is 116, what will be its maximum life in per cent of normal?

7.—Assume that the lamp in Problem 6 had a life of 1,000 hours at its rated voltage.
(*a*) How long would it last, in days, if it is burned on an average of two hours each night at a voltage to give 0.8 of its normal life?
(*b*) If this had been a lamp rated at 110 volts, what is the voltage at which it was burned?

Second Lesson—Curve Reading

8.—(*a*) In Plate 5, assume that the generator is operating arc lamps connected in series. If each lamp requires 50 volts for its operation, how many would have to be connected on the circuit to obtain 67 per cent efficiency from the generator?
(*b*) How many for the generator to operate at 80 per cent efficiency?
(*c*) What is the voltage, and how many lamps in operation for 90 per cent efficiency?

9.—(*a*) If this was a direct current machine and it required 10 amperes for the operation of the lamps in Problem 8 (*b*), what is the output of the machine in kilowatts, disregarding the line loss?
(*b*) What horse-power is the equivalent of this number of kilowatts?

10.—From the curves in Plate 6, what is the weight of a 7 inch 45 foot chestnut pole?

11.—How does the weight of a 6 inch 30 foot chestnut pole compare with the same length of 7 inch and 8 inch poles?

12.—What lengths of 6 inch and 7 inch chestnut poles weigh the same as an 8 inch 30 foot pole?

13.—If, with the micrometer, a wire was found to measure 0.102 inches in diameter, what standard size would this indicate, according to Plate 7?

14.—What would a half-mile coil of this size wire weigh?

15.—If the wire was newly erected, what would be the safe current for it to carry without undue heating and consequent increase in resistance and line loss?

16.—What current could it carry after it became well blackened?

Third Lesson

17.—What size N. B. S. is the same diameter and weight as No. 8 B. & S.?

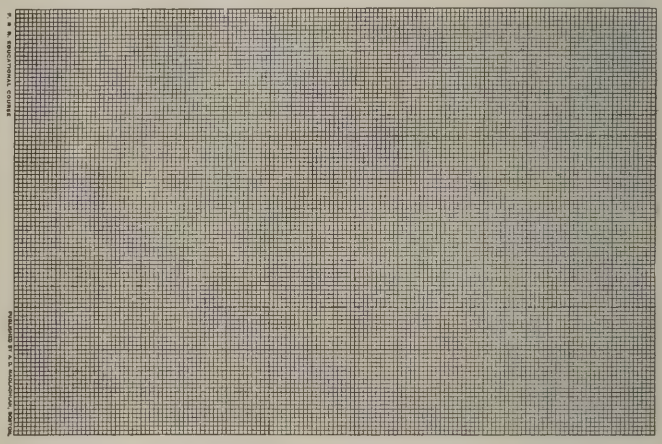
18.—From the curve, what is the difference in weight of 110 mil and No. 9 B. & S. gauge copper wire?

19.—(*a*) What is the difference in weight per mile of No. 9 B. W. G. and No. 9 B. & S. copper wire?
(*b*) What is the difference in their diameters?
(*c*) What is the ratio of the safe current in blackened wire which No. 9 B. W. G. can carry to that of No. 8 B. & S.?

20.—(*a*) If a copper wire were made having a diameter of 140 mils, what would it weigh per mile?
(*b*) What current could it safely carry after it became well blackened?

21.—A wire in a conduit must carry 200 amperes. What must be its diameter?

22.—What would be the rise in temperature of a blackened wire in still air at 20° C. if its diameter was 0.75 inch and it was carrying 600 amperes?



Cross Section Paper to be Used in Plotting Curves

23.—Show by means of curves on the same sheet, the difference in the breaking strain of E. B. B., B. B., and steel wire, as shown in wire table in E-2.

24.—From this same table, draw curves showing the difference in the resistance of E. B. B., B. B., and steel wire.

NOTE.—The curves for the last two questions should be drawn on the cross-section paper furnished for this purpose with the pamphlet.

The Railroad Electricians' Club

Meetings the 3rd Monday of Every Month, 8 P. M.—18th Floor Transportation Bldg., Harrison and Dearborn Sts., Chicago—Everybody Welcome—No Dues

Review Lesson on Ohms Law

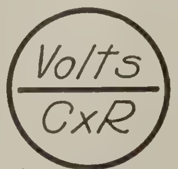
Prob. 1. What is ohms law, and why is it so important in electrical work?

Ans. 1. Ohms law is mimply *"The current which flows in a circuit is equal to the voltage divided by the resistance of the circuit."* Or "C" is equal to "E" divided by "R". This is the fundamental law upon which all calculations of current voltage and resistance are based. It is without doubt the most important thing to be taken up in this course of lessons so every student should make sure that he has a full understanding of this law and knows how to use it.

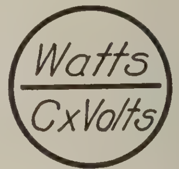
Of similar importance is the law of power in electrical circuits, which is that *"The number of watts (power), is equal to the number of amperes (current) times the number of volts (pressure)"* or "W" is equal to "C" times "E".

Prob. 2. Give an easy rule for remembering this law.

Ans. 2. The accompanying diagrams, which were originally submitted by one of our readers, give an easy rule for remembering Ohms law and for figuring power in a circuit.



Easy Rule for Remembering Ohms Law



Rule for Figuring Power Volts and Current

Considering the first diagram, it is only necessary to cover up the unknown quantity with your finger and the two remaining known quantities will give the answer. For instance, if the volts and current in a circuit are known, by covering up "R" in the diagram we find that the volts divided by current gives the resistance, or if current and resistance are known, but the voltage required unknown, cover up "volts" in the diagram and we find that the answer is current × resistance, which gives the number of volts required; similarly, if current is unknown and volts and resistance known, the current flowing will be the number of volts divided by the resistance.

In the same way if the watts and volts in a circuit are known, by covering the unknown "C" in the second diagram we find that the current flowing is equal to the watts divided by the volts; if the watts are unknown, by referring to the diagram and covering "watts" with the finger, we find that the current times volts gives the number of watts in the circuit.

Prob. 3. If a resistance of 1 ohm is connected across a 2-volt battery, the internal resistance of which is negligible, what current will flow?

Ans. 3. Since the current flowing will be the volts divided by the resistance (2 divided by 1), there will be 2 amperes of current flowing in this circuit.

Prob. 4. If another battery is connected in series with the first one, making 4 volts total, and the same resistance connected across these two cells, how much current will flow?

Ans. 4. If the voltage is doubled and the resistance remains the same, the amount of current flowing will be doubled, or figuring this as we did in the problem above, volts divided by resistance (4 divided by 1), we find that there will be 4 amperes flowing, or twice as much as in problem 3.

Prob. 5. If a 4-ohm resistance is connected across the 4-volt battery circuit, how many amperes will flow?

Ans. 5. With the voltage of 4 volts and a resistance of 4 ohms the current will be volts divided by resistance (4 divided by 4 or) 1 ampere.

Prob. 6. What is meant by an ampere hour?

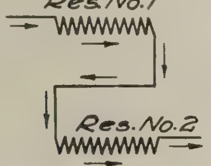
Ans. 6. An ampere hour means a current of one ampere flowing for one hour. It has no reference to the voltage of the circuit and hence is no measure of power. In other words, 2 ampere hours delivered by a 2-volt battery would only represent 1/10 of the amount of power that two ampere hours flowing from a 20-volt battery would. The ampere hour is simply a measure of current and time, and is found by multiplying the number of amperes × the number of hours that the current is flowing.

Prob. 7. If a storage battery discharges a 2-ampere current for 4 hours, how many ampere hours are taken from the battery?

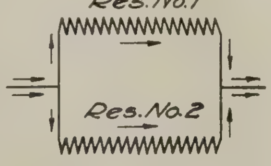
Ans. 7. The number of ampere hours as stated above, is simply the product of the number of amperes flowing × the number of hours (2x4 or) 8 ampere hours.

Prob. 8. What is the difference between resistances being connected in series and in parallel?

Ans. 8. When two resistances are connected in series it means that they are connected so that all of the current flowing through the circuit must pass through both of the resistances. This connection is shown in Fig. A.



Resistances in Series



Resistances in Parallel

When these same two resistances are connected in parallel it means that the ends of each of these resistances are connected together and the current flowing through the circuit divides, only part going through each resistance. In other words, the two resistances in parallel provide two paths for the current instead of one, as formerly, and this combination always offers less resistance to the flow of current than when either one of the coils, or the two in series, are placed in the circuit.

Prob. 9. What is the joint resistance in a circuit containing 2 resistances of 1 ohm each in series?

Ans. 9. With two resistances in series the joint resistance is simply the sum of the two, since the total current must pass through both of these resistances. With two resistances in series then of one ohm each, the total resistance will be 1 plus 1, or 2 ohms.

Prob. 10. What is the joint resistance of a circuit containing two 1-ohm resistances in parallel?

Ans. 10. In figuring resistance in parallel instead of adding their resistances, we add their conductivities. Conductivity is the reciprocal (inverted fraction) of the resistance, so by figuring the conductivity of each of the resistances and then adding, we get the total conductivity of the circuit. With two 1 ohm resistances in parallel the conductivity of each would be (1 divided by 1). Hence the joint conductivity would be 1 plus 1 or 2. The resistance is the reciprocal (inverted fraction) of conducticity so by inverting the fraction 2/1 we find that the resistance of this combination is ½ an ohm.

Prob. 11. What is the joint resistance of a circuit containing 4 ohms in parallel with 2 ohms?

Ans. 11. The conductivity of the 4 ohm resistance is ¼, and of the 2 ohm resistance ½, so the joint conductivity of the two will be (½ plus ¼ or) ¾. The joint resistance is then the reciprocal of this (inverted fraction) or 4/3, giving the answer as 1⅓ ohms with 4 ohms and 2 ohms in parallel.

Prob. 12. What is the joint resistance of a circuit with 4 ohms in series with 2 ohms?

Ans. 12. Where these resistances are conected in series the joint resistance is simply the sum of the two individual resistances (4 plus 2 or) 6 ohms total.

Prob. 13. If 4 ohms, 2 ohms and 1 ohm are all connected in parallel, what is the joint resistance of the combination?

Ans. 13. Where three or more resistances are connected in parallel the principle of figuring the joint resistance is the same as when there are only two, that is, find the conductivity of each resistance and the sum of all conductivities gives the joint conductivity of the combination, from which resistance can be easily figured.

The conductivity of 4 ohms is ¼; of 2 ohms ½; of 1 ohm 1/1, therefore the joint conductivity of the combination is 1¾ or 7/4. The joint resistance is then the reciprocal (inverted fraction) of the conductivity, so by turning this fraction up-side-down we get 4/7 of an ohm as the joint resistance of the combination.

Prob. 14. If a circuit made up of 200 ohms and 400 ohms in series is connected in parallel with a 300-ohm resistance, what is the joint resistance of the combination?

Ans. 14. The joint resistance of the two resistances in series must first be figured, which gives us (200 plus 400 ohms or) 600 ohms.

This resistance of 600 ohms is conected in parallel with a 300 ohm resistance, therefore proceeding as in previous problems, the conductivity of the 300 ohm resistance is 1/300, the conductivity of the 600 ohm resistance is 1/600; therefore, adding these we find the sum to be 3/600, or 1/200 as the joint conductivity of all resistances.

Taking the reciprocal (inverted fraction) of this last fraction, we get 200 ohms as the joint resistance of the whole combination.

Prob. 15. What is the difference between a watt and an ampere?

Ans. 15. An ampere is simply a measure of rate of flow. It has no reference to the pressure or voltage. A watt is a measure of power and is the product of amperes × volts. A good illustration of these two quantities will be found in considering the flow of water. If we have water coming from a nozzle at the rate of one gallon per minute this would correspond to the ampere; but if we have that water coming from the nozzle under a certain pressure so that the water comes out with considerable force, the amount of that force is the product of the quantity of water flowing times the head of the water; this corresponds to the watt. Things which measure power, horsepower, watts, etc., always consider both rate of flow and pressure.

Prob. 16. (*a*) How much current does a 60-volt, 25-watt lamp require when operated on a 60-volt circuit? (*b*) How much does a 30-volt 25-watt lamp require when operated on a 30-volt circuit?

Ans. 16. (A) Referring to the diagram in problem 2, we find that where the current is unknown, by covering "C" the answer in found to be watts divided by the voltage. A 25-watt lamp on a 60-volt circuit will require (25 divided by 60 or) .417 of an ampere. (B) A 25-watt 30-volt lamp when operated on a 30-volt circuit will require (25 divided by 30 or) .834 of an ampere.

Prob. 17. How much current will a 110-volt, 25-watt lamp consume when operated on a 110-volt circuit?

Ans. 17. To find the current consumed in this case, we proceed exactly the same as in previous problem by referring to the diagram problem 2, or if we remember that watts are simply amperes times volts, we can find the number of amperes consumed by dividing the number of watts by the volts (25 divided by 110) which gives us .228 of an ampere.

Prob. 18. Four 25-watt lamps and three 15-watt lamps of a 110-volt type are switched on a 110-volt circuit, what will be the total current consumed?

Ans. 18. To get the total wattage of the circuit we simply add that of the four 25-watt lamps and three 15-watt lamps, which give us 145 watts total consumed. Then proceeding as in previous problems we find that the current is watts divided by volts (145 divided by 110 or) 1.32 of an ampere consumed in the circuit.

Prob. 19. (*a*) What is the resistance of a 25-watt, 30-volt car lighting lamp? (*b*) Of a 25-watt, 60-volt car lighting lamp?

Ans. 19. (A) This is really two separate problems, first to find the amount of current flowing, and second to compute the resistance of the lamp. In problem 16 we found that a 25-watt 30-volt lamp consumed .834 of an ampere, then referring to the diagram, problem 2 and covering up the unknown "R" we find that the resistance is the volts divided by the current (30 divided by .834 or) 36 ohms, which is the resistance of the lamp.

(B) In problem 16 we found that a 25-watt 60-volt lamp would consume .417 of an ampere. Therefore, again referring to the diagram Fig. 2, and covering "R", we find that the resistance is equal to volts divided by current (60 divided by .417 or) 144 ohms. It should be noted that this is 4 times the resistance of the 25-watt lamp. This is because it must cut the current down half on twice the voltage.

Prob. 20. What current will flow through a 60-volt car lighting lamp when connected across a 34-volt axle generator as pilot lamp?

Ans. 20. From the preceding problem we found that a 25-watt 60-volt lamp has a resistance of 144 ohms. When this resistance is connected across a 34-volt axle generator the current flowing will be found upon referring to diagram in problem 2 to be volts divided by resistance (34 divided by 144 or) .236 of an ampere. This is only about half normal lamp current so the lamp will only be lighted to about half brilliancy, or less.

Prob. 21. Suppose a 30-volt, 25-watt lamp and 50-volt, 25-watt lamp are connected in series across a 60-volt circuit, how much current will flow and what is the total resistance?

Ans. 21. From problem 16 we find that the resistance of a 25-watt 30-volt lamp is 36 ohms. To find the resistance the 50-volt 25-watt lamp we must first find the current flowing, watts divided by volts (25 divided by 50 or) ½ an ampere. The resistance of the lamp consuming ½ ampere on a 50-volt circuit must be volts divided by current (50 divided by ½ or) 100 ohms.

With the two lamps in series, one of 36 ohms and the other of 100 ohms, we have a total of 136 ohms resistance. When this is placed across a 36-volt circuit the current flowing will be volts divided by resistance (60 divided by 136 or) .441 amperes. The total resistance as mentioned above, is 136 ohms.

Prob. 22. What is meant by the k. w. hour?

Ans. 22. As explained in problem 15, the watt is a measure of power. This, however, means nothing as to the total amount of energy consumed or work done.

A stream of water discharged with such velocity that it generates one horsepower, when working for one hour will do a certain amount of work, called one horsepower hour. In the same way, a watt of electrical energy in a circuit operated for one hour, represents a certain amount of energy, called a watt hour.

Kilo means a thousand, so a kilowatt hour is simply a thousand watt hours. This is found by multiplying the number of amperes × the number of volts × the number of hours and divide by 1,000.

Prob. 23. If the rate of 8c per k. w. hour is charged, what will be the cost of ten 40-watt, 110-volt lamps on 110-volt circuit for six hours?

Ans. 23. Ten 40 watt lamps will consume 400 watts, which operating for 8 hours would represent (8 times 400 or) 3,200 watt hours. This is the same as 3.2 k.w. hours since one k.w. hr. is the same as 1,000 watt hours. This, at the rate of 8c per k.w. hour would cost 25.6c for burning these lamps for this time. It should be noted that the actual power consumed by a 40-watt 110-volt lamp on a 110-volt circuit is the same as a 40-watt 30-volt lamp on a 30-volt circuit, or as a 40-watt 60-volt lamp on a 60-volt circuit.

Problems for Next Month

Review Lesson on Ohms Law.

Problem 24—Compare the conductivity of an electric conductor with the conductivity of a water pipe.

Problem 25—What elements determine the resistance of a wire?

Problem 26—What effect has the cross section upon the resistance of a wire?

Problem 27—What effect has length of a wire upon its total resistance.

Problem 28—What effect does heat have upon the resistance of insulators?

Problem 29—What is temperature co-efficient of resistance?

Problem 30—About how many degrees Fahrenheit change will be required to change the resistance of copper wire by 1%?

Problem 31—What is meant by line drop?

Problem 32—What effect does the voltage of a circuit have on line drop, assuming the same wire and power delivered in each case.

Problem 33—On a 110-volt circuit it is desired to run a line to a 10 h.p. pumping motor 2,000 ft. distant. If the maximum line drop allowable is 10%, what size of wire will be required?

Problem 34—What would be the size of wire required for a 110-volt lighting circuit containing fifty 60-watt lamps, assuming the maximum line drop, or voltage variation, to be 5%. The length of the circuit from the power house to the distributing board is 1,000 ft.

Problem 35—What size of wire will be used for ten 60-watt lamps from the distributing board in Problem 34 to the lamps? Voltage distance, 100 ft.

A. B. C. Car Lighting Course

Edited by Edward Wray

The first lesson of this course was published in our Feb., 1912, *issue. All back numbers covering over two years' work can be furnished, bound in heavy paper covers with special binding arrangement, so that future lessons can be added and preserved. This also includes all back lessons of the P. R. R. School of Electricity, the R. R. Electricians' Club, Prize Question Box, and Practical Stunts. Price* $1.00. *(See blank on page* 6.*)*

Lesson No. 29

The Adams & Westlake Newbold System

The new axle car lighting generator equipment recently placed on the market by The Adams & Westlake Company, although very similar in design to the original Newbold System, as published in our lesson No. 14, contains many novel features which warrant further consideration in this course of lessons.

Generator.

The generator is an entirely new design, being made much lighter and more compact than the original Newbold generator, although the liberal copper section of the old machine in both armature and field coils and commutator has been retained in the new machine. The frame of the generator consists of a drawn steel tube of high permeability, which makes possible its light weight. The field windings are form wound so as to fit the contour of the inside of the case. A large hand hold cover may be removed, which provides easy access to brush rig and commutator and the entire end of the machine may be removed for inspection of the pole changer gear.

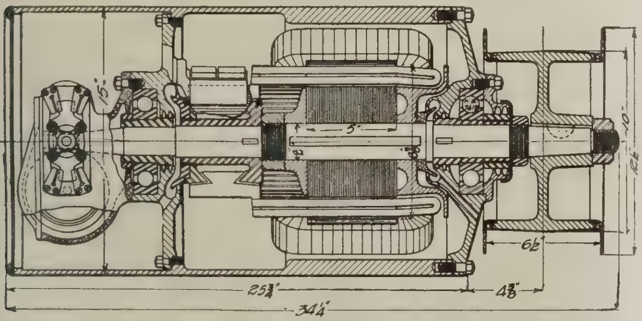


Fig. 161. Cross Section of Newbold Generator Showing Ball Bearings, Pole Changer Switch, Etc.

The generator is a four pole simple shunt wound machine and brush contact is made at but two points, 90 degrees apart. This brings both of the brushes on the same side of the commutator, where they are easily accessible from the hand hole. This illustrates an interesting principle of the four pole d.c. generator, which is that four brushes may be employed, placed at 90 degrees apart, and the brushes diametrically opposite connected in parallel to the external circuit; or it is possible by cross connecting the coils within the armature, to simply eliminate two of these brushes and take the current from any two adjacent brushes 90 degrees apart. The same result can be obtained by employing a series wound armature having but two paths for the generator current passing through the armature. The latter style of winding is employed in this equipment.

The armature is drum wound with semi-closed slots and the armature coils consist of ribbons of copper, three ribbons to a slot. A fibre strip acts as a wedge to hold the coils in place throughout the full length of the armature. Duplicate brushes with separate adjustable spring tension device for each, as shown in Fig. 162, are provided for commutating at each of the two neutral points: These brushes, being in duplicate largely prevent brush failure, for either one of the brushes has ample commutating area to carry the entire output of the generator.

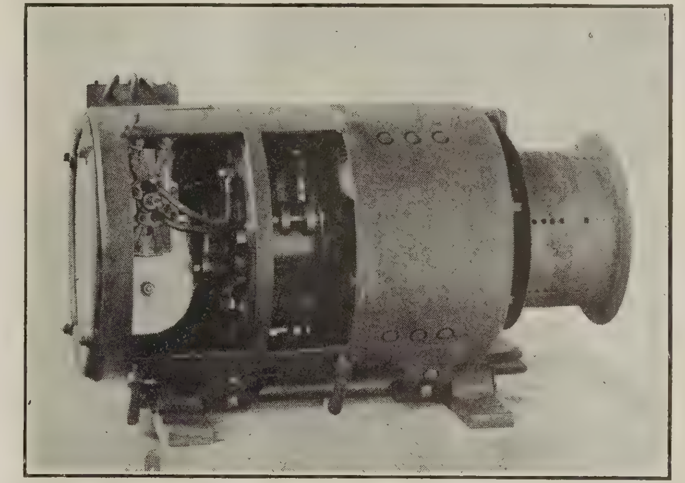


Fig. 162. Generator with Inspection Covers Removed.

The generator is designed to accommodate any of the standard makes of ball bearings. The bearings are mounted on a sleeve as shown in the section diagram of the generator, Fig. 161.

Pole Changer.

The pole changer is a very simple and ingenious device, which consists of a worm wheel driven by a worm on the end of the armature shaft. To this is connected a steel disc about 6 in. in diameter which has a single radial slot 2 in. deep. The dog of the throw over switch rests upon the rim of this disc and when the direction of the motion is reversed, the dog drops down into the slot and is carried forward as the disc is driven by the worm wheel. This throws the change over switch, which reverses polarity of the armature terminals and compensates for the reversal in direction of motion. 105 revolutions of the armature, the equivalent of about 500 ft. of train movement will reverse the pole changer, provided it has to move through a maximum angle before changing connections. Since the worm wheel runs light, except when actually reversing connection, the wear on pole changer parts should be slight.

Dynamo Regulator.

The output of the generator is controlled by automatically adjusting the resistance in series with the generator field to compensate for variation in train speed. It will be noted from referring to the wiring diagram, Fig. 163, and also the view showing the panel board, Fig. 164, that a sprocket wheel arrangement with chain carries the iron plunger of the main solenoid on one side, which is considerably overbalanced by the weight of a bucket of shot encased in a dash pot on the other side. The magnetic pull of the current flowing through the main solenoid draws the iron plunger downward and lifts the weighted bucket on the other side as soon as the automatic switch closes and the generator current tends to rise above normal. The maximum current which can be delivered depends upon the amount of shot in the dash pot bucket. The greater the weight of the shot, the greater will be the current required to pull down the solenoid and overbalance this weight.

It will also be noted that a contact arm is mounted upon this wheel and on the end of this arm is a small carbon brush which makes contact with commutator segments connected to the generator field resistance. As the solenoid plunger is drawn downward by the effect of the generator current flowing through the solenoid, the brush at the end of the contact arm sweeps over the field resistance segments and gradually inserts resistance in the generator field, thereby cutting down the generator field current to compensate for the rise in train speed and maintaining the generator output at the proper value.

It will be noted from the wiring diagram, Fig. 163, that the main regulating solenoid is divided into five separate windings, as follows: (S1) 160 turns of No. 5 wire; (S2) 96 turns of No. 8 wire; (S3) 64 turns of No. 9 wire; (S4) 107 turns of No. 10 wire; and (S5) 250 turns of No. 12 wire. It will also be noticed from following out the connections of the wiring diagram that when the lamp switch No. 1 is thrown to the off position (day charge with no lights in use), only the heavy No. 5 turns of the solenoid winding are carrying current, the other coils being short circuited by the throwover switch.

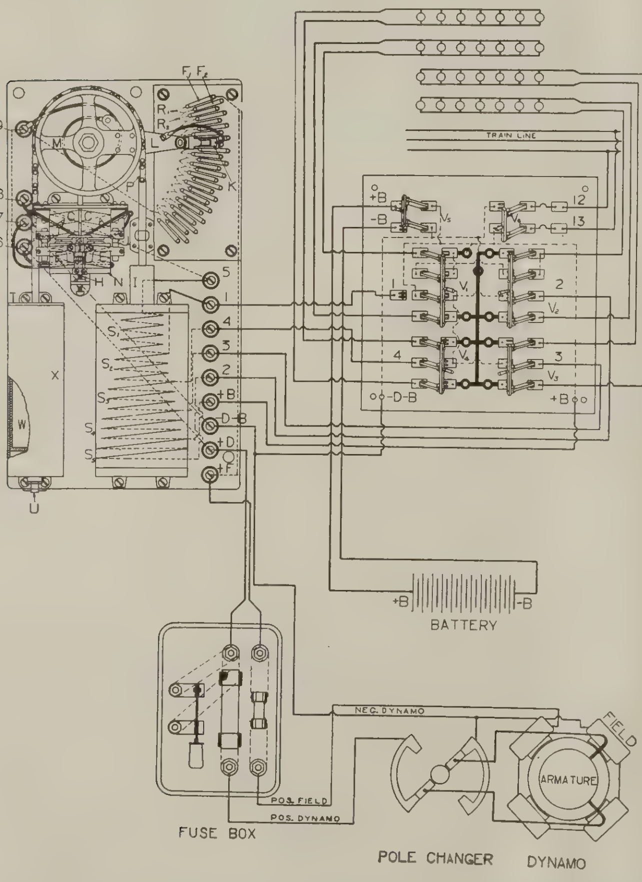


Fig. 163. Wiring Diagram of Newbold System. Note that Lamp Switch Short Circuit Sections of Winding on Regulating Solenoid.

This provides then, that the current output of the generator will be maximum under day conditions, since only the 160 turns of the No. 5 wire in the solenoid are in circuit.

It should be understood that the unbalanced weight of the shot requires a certain number of ampere turns of magnetising force in the solenoid in order to lift that weight. Whether this number of ampere turns comes from a heavy current through a small number of turns, or a small current through a large number of turns, is immaterial as far as the operation of the regulator is concerned so long as the product of amperes times turns is constant.

The number of turns in each of the 5 coils is adjusted so that with the average circuits the generator output is automatically adjusted so as to increase approximately the number of amperes lamp power switched on. As stated above, under day conditions, with no lights on, current flows only through the 160 turns of heavy wire, shown as S1, Fig. 163. Under these conditions, switch No. 1 is thrown to the left, making contact with the switch blade, which allows current to flow through the regulating solenoid. When this switch is thrown over to the right, it establishes entirely new connections in the solenoid circuit, so that the entire current general flows through all of the five coils of the regulating solenoid. Since the number of effective turns in the solenoid are then greatly increased, the current output of the generator is correspondingly reduced as shown in the accompanying table.

Closing switch No. 1 automatically supplies current to switch No. 2, so when this latter switch is closed the second light circuit will be turned on and at the same time the outer winding, (S5) of the solenoid will be short circuited. Since the number of turns in the solenoid is reduced by short circuiting the S5 winding, the current output of the generator must increase correspondingly in order to produce the required number of ampere turns magnetizing force. The S5 winding of the solenoid is designed so that the increase in generator output when it is short circuited just about makes up for the increase in lamp load when that circuit is turned on. The current into the storage battery will then be maintained practically constant, as shown by the accompanying table. There is but a rise of from 6 to 8 amperes battery charge with an increase in generator output from 16 to 25 amperes.

It should be noticed that switch No. 2 is entirely dead and no lights can be obtained by closing it until after switch No. 1 has been closed. Similarly switches No. 3 and 4 are dead until after switch No. 2 has been closed.

Upon closing switch No. 3, the third circuit of the car is lighted and one leg of the switch automatically

TABLE SHOWING VARIATION OF GENERATOR AND BATTERY CURRENT WITH DIFFERENT LAMP LOADS.

Lamp Switches Thrown	Lamp Current	Battery Charging Current	*Generator Current
No. 1 to Left	0	49	49
No. 1 to Right	10	6	16
No. 1 and 2	17	8	25
No. 1, 2, 3	23	9	32
No. 1, 2, 3, 4	26	6	32
Shot Added to Increase Generator Output.			
No. 1 to Left	0	55	55
No. 1 to Right	10	7	17
No. 1 and 2	17	10	27
No. 1, 2, 3	23	12	35
No. 1, 2, 3, 4	27	11	38

---

*Generator field current not included.

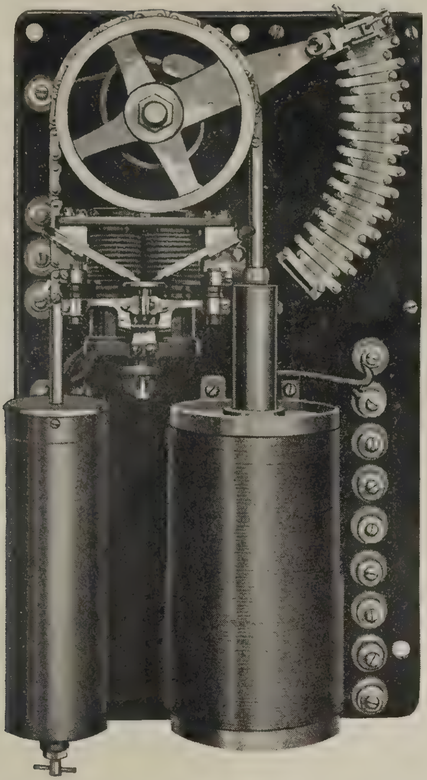


Fig. 164. Regulator Panel for Newbold System.

short circuits the S2 winding of the regulating solenoid. from 25 to 32 amperes, which takes care of the increased This increases the generator output, as explained above, lamp load so that the current to the battery is kept approximately constant, increasing from 8 to 9 amperes, as shown in the accompanying table.

Upon closing switch No. 4, the S3 winding of the solenoid is short circuited and the generator output again increased to take care of the increase in lamp load.

With all lights on, then current flows through simply the S1 and the S2 coils of the solenoid. This will provide that the total output with all lights on is somewhat less than when all lights are turned off, as shown in the accompanying table, the ratio being 32 to 49.

The figures given in the table showing generator output do not include field current. This varies from 2 to 6 amperes, depending upon the speed.

In order to show the effect on battery charge current with different adjustments of the regulator, enough shot was added to the dash pot plunger to raise the generator current, under day charge conditions, from 49 to 65 amperes. The effect with various switches closed may be seen from the accompanying table. It will be noted from comparing the battery current under the two different settings that the increase of six amperes in battery charge, under day conditions, produces an increase of 1 ampere with switch No. 1 closed, 2 amperes with No. 2 closed, 3 amperes with No. 3 closed, and 5 amperes with No. 4 closed.

This is about what would be expected when we remember that with only switch No. 1 closed, the additional one ampere current flowing through all of the windings would produce the same increase in ampere turns as the increase of 5 amperes with all switches closed and with the current flowing through only coils S1 and S2.

Although the above table would indicate that most of the battery charge must be done in the day time, the ratio of turns in the various coils of the regulating solenoid can easily be adjusted to produce almost any desired result, from the float condition in which the battery current is kept at approximately zero when all lamps are in use, which would insure nearly uniform lamp voltage, to a condition of constant battery current charge in which the generator output is automatically increased to take care of the increase in lamp load. The battery current meanwhile being maintained constant.

At the present time the manufacturers do not supply a lamp voltage regulator, since they consider that the rate of battery charge at night is so low that it would cause only a slight variation in generator voltage under night conditions.

Control of Battery Charge.

An ampere hour meter of the variable resister type can be placed in the battery circuit, where desired, which automatically records both the charge and discharge of the battery, and makes a contact when the meter indicates full battery which trips a double pole relay, opening the generator field circuit. If lamps are then on the battery will begin to discharge and when it reaches the 15 ampere hour point on the dial a second contact will be made in the meter which will close a circuit through a second coil of the double pole relay; this will throw it over in the reverse direction and close the circuit through the generator field. This will re-establish normal operating conditions and the axle equipment will then begin to charge the battery again until this 15 ampere hour discharge has been replaced, plus the required percentage overcharge.

Consolidated Co. Adopts Ampere Hour Meter as Standard Part of Axle Equipment.

The Consolidated Ry., Elec. Ltg. & Equip. Co. advise that they have recently adopted the ampere hour meter as a standard part of their type "L" axle equipment. The ampere hour meter is employed for not only measuring the amount of charge and discharge, and at all times indicating the amount of charge available in the battery. The meter is connected so as to actually control the operation of the axle equipment, making a contact which stops further charge when the battery has been brought up to a full state of charge as measured in ampere hours.

"A Manual of Electrical Testing."

This is the subject of a new 48-page bulletin, size 8 in. x 10½ in., issued by the Wagner Electric Mfg. Company, of St. Louis. Besides describing the line of portable instruments manufactured by the Wagner company, this bulletin describes various types of electrical instrument movements, the errors to which they are subject, and gives suggestions for their handling and care.

The methods for making electrical tests on alternating current and direct current motors and generators and on transformers are described at length and illustrated by comprehensive and instructive diagrams. The publication is one that should be in the hands of everyone who has anything to do with the use of electrical instruments on railroads and copies may be had upon application to the Wagner company.

New Porcelain Socket.

The Pass & Seymour Company of Solvay, New York, has recently put on the market a new porcelain socket. This socket is an addition to the lines of interchangeable porcelain sockets manufactured by this company. The socket is equipped with a ½-inch aluminum cap and has a key for snap switches.

Prize Question Box

This "Question Box" is open to every electrical man in the Mechanical, Signal and Telegraph, as well as Car Lighting Departments. We feel that this can be made a mighty valuable thing, so as a special inducement to the boys to boom it, we offer prizes for the best questions asked, as follows:

First prize	$1.00 *in cash*
Second prize	9 *months' subscription*
Third prize	6 *months' subscription*

There are some questions that are of a general nature, which should have comments of prominent men of experience. These will be published under "Questions Before the House," and we hope that prominent railroad men and manufacturers will discuss these questions. All answers published will be paid for at $1.00 *each.*

Questions Before the House

Field Fuse Trouble.

No. 3. On Bliss equipments I find that the shunt fuse will almost invariably blow if the automatic switch does not close or if there is an open in the battery circuit. But on the Moskowitz type of equipment I quite often find that the automatic switch does not close and yet the shunt fuse does not blow as it would in a Bliss equipment. Will you try to furnish an explanation?—S. W. Everett, Santa Fe.

Current in Moskowitz System.

No. 4. Why does the current run up on a Moskowitz equipment as the speed of the train increases? That is, if the dynamo is set for 30 amperes when the train is running at 30 miles an hour and when the speed of the train increases to 50 miles per hour, you will find that the output of the machine has raised almost double, to perhaps 45 or 50 amperes.—A. E. Voigt.—Santa Fe.

Water for Flushing Batteries.

No. 6. Why do battery manufacturing companies prescribe that only absolutely pure distilled water must be used for flushing the cells, when if pressed they will all admit that it is permissible to use Lake Michigan water? Is this water of equal purity with distilled water?—J. L. Ohmans, Elec. Fore., C. & W. I. Ry.

System of Handling Repairs to Axle Equipment.

No. 7. What is the best method of handling repairs to axle devices? That is, is it better to make repairs on each device enroute or at terminals as soon as the trouble develops or, by having a few spare equipments, simply replace the complete board or the complete generator which is giving trouble and make the necessary repairs in the shop?—L. S. Billau.

Ampere Hour Meters in Car Lighting Service.

What attention has it been found necessary to give ampere hour meters in car lighting service to maintain them properly? How frequently should they be removed from cars and taken into shop for thorough overhauling?—L. S. Billau, B. & O. Ry.

Excessive Heating of 110-60 Volt Train Lighting Generators.

The turbine driven generators in our head lighting service were changed from 110 volt to 60 volt operation a few years ago. When this was done an extra resistance unit was placed in the shunt field of the generator and a shunt of proper resistance connected across the compound field. Some of the machines give serious trouble due to overheating and the men report that this seems to be caused by the shunt on the series field.

It is possible to operate the generator without this series field shunt when lamps alone are connected as a load on the generator. But when the batteries are connected, regardless of their conditions of charge, the voltage of the machine is very difficult to control without the shunt on the compound field.

Why should these generators heat excessively, and why should it be possible to control the voltage without the shunt when lamps alone are on the generator, but be impossible to do so when batteries, with or without lamp load, are connected?—C. R. Gilman, Chief Elec., C., M. & St. P. Ry., Milwaukee, Wis.

Weak Cells in a Battery.

In testing out batteries which are in a partly discharged condition, it happens that one or more cells show a reversed polarity when the test is made with load on the batteries. After disconnecting the reversed cells, however, they show a weak voltage in the right direction. Are the cells so affected actually reversed, or is the internal resistance of the cells so high that current goes through the voltmeter in the wrong direction when the cells are in circuit with the set?—W. M. Wiggins, Pullman Co., St. Louis.

Voltage of Edison Batteries.

Is the voltage of the Edison battery affected by standing idle for a few days in extremely cold weather?—G. B.

Reversal of Battery Cells.

Why will one or more cells in a battery become reversed without any apparent cause for so doing?—Z. Humphrey, Santa Fe, San Bernardino, Calif.

Ground on Type "K" Relay.

What effect will a ground on a type K relay have on the operation of the U. S. L. equipment?—Frank M. Burke, Pullman Co., Jersey City.

First Prize

Axle Generator Suspension.

Does a rigid axle generator suspension possess any advantage over that using spring tension; and, if so, under what conditions?—L. S. Billau, B. & O. Ry.

TO THE EDITOR:

The question of the relative merits of the rigid generator suspension and that using spring tension, is an interesting one. The rigid type of suspension possesses many advantages but there are one or two disadvantages, chief of which is the inability to standardize the amount of tension placed on the belt. It is apparently impossible to control the action of the men located in the various yards—the opinion of a man in Chicago, will be diametrically opposed to the opinion of a man in New York. One will probably put too much tension on the belt and the other too little. If a suitable gauge or measuring instrument could be devised whereby the amount of tension placed on the rigid type of suspension belt could be measured, one of the most serious difficulties would be overcome.

Another difficulty encountered in the rigid type of suspension is the pulleys running out of true, the pulley and axle not being concentric, due to application of pulleys to either rought or smooth forged axles, or the use of some of the flexible bushings that are now on the market. With the use of the rigid type of suspension, it does not take long to jerk a belt apart at the clamps with a pulley that is running out of true. Good belting that stretches very little under proper operating conditions is obtainable, although some purchasing agents still insist upon buying the cheaper forms of belting, which in the long run is poor economy.

It is my opinion that sometime in the future we will be using rigid type suspensions with some of the later forms of solid woven belting, providing we can induce the master car builders to turn their axles, use the proper kind of bushings in the pulleys and maintain the pedestals and journal boxes in good repair and thus preserve the alignment of the axle.—Thos. L. Mount, Consolidated Ry., El. Lt. & Equip. Co.

Second Prize

Efficiency of Lead Battery at Various Rates.

Is there any difference in the ampere hour efficiency of a lead battery when charged at a high rate and at a low rate? Does this also vary with the frequency of charge? In other words, is there any definite ampere hour efficiency which may be selected which will take care of battery operation in car lighting service?—J. E. Gardner, Elec. Engr., C. B. & Q. R. R.

To the Editor:

If a storage battery is charged and discharged over a small part of the battery capacity or over full battery capacity, there will be little difference in the ampere hour efficiency noted in each case. The k. w. hour efficiency, however, will, of course, be very much higher where the battery is charged and discharged over a short range frequently but without being brought to a full charge at high rate, as would be experienced in street railway floating battery service.

There is a certain leakage loss on standing, which greatly affects the ampere hour efficiency of a battery when it is left standing for any length of time. In fact, in central station stand-by service, where the storage batteries are sometimes not discharged for weeks, they still require a certain amount of charge to keep the battery up to full capacity. In other words there is a constant leakage of current on standing which must be replaced. Under these conditions, of course, the ampere hour efficiency would be zero.

Only practical experience will show what is a safe ampere hour efficiency at which ampere hour meters may be set to control the operation of storage batteries in car lighting service, and this will vary somewhat depending upon the frequency of charge and discharge.

H. M. Beck, Electric Storage Battery Co.

Third Prize

Smooth Forged vs. Rough-Turned Axles.

Is any railroad obtaining successful results in the application of axle pulleys to smooth forged axles in place of rough turned axles?—L. S. Billau, B. & O. Ry.

New York, May 19, 1914.

To the Editor:

This question brings to mind experiences that some of the older men in the axle light business had years ago, when axle light was first being applied to cars. It was a most difficult matter to convince the average master car builder that it was necessary to turn an axle for the purpose of applying the pulley, until a practical demonstration was made before his eyes of the effect of running an axle pulley mounted from 1/8 to 1/4 inch or sometimes from 1/8 to 1/2 inch eccentrically at several hundred revolutions per minute. At a slow speed this eccentric motion of the pulley is not detrimental to the belt, but at the higher speeds the force of the blow or jerk on the belt is terrific. It would involve some mathematics to calculate the exact force of this jerk on the belt when the axle pulley is revolving at 500 rev. per minute.

The mounting of axle pulleys on smooth forged axles, has been the cause of many belts being lost. When you consider the fact that the dynamo itself is in more or less unstable equilibrium and can rock back and forth as the belt or spring tension predominates, the stresses and strains that are put upon the generator shaft and the belt fastener, although not easily estimated, can well be imagined. It will be found that the circumference of very few rough turned axles will be absolutely concentric with the center holes in the ends of the axle that were used for turning the journals of the axle, and it is for this reason, that it is necessary to true the axle up at the point where the pulley is applied by rough turning it. Of course, there are always those among us, who are willing to take a chance on the smooth forged axle being concentric with the journals. My own experience has been that it does not pay. It was for the same reasons that felt, paper and wood were discarded as pulley bushings and solid metal bushings adopted in their place; any pulley that does not run true, puts the operator of the axle light equipment at a disadvantage when trying to reduce his cost of belt maintenance.

I do not believe it possible for anyone to obtain successful results in the application of an axle pulley to a smooth forged axle—those who do it may be *satisfied* with the results, but I venture the opinion that they will not prove successful when compared with results obtained from rough turned axles.—T. L. Mount, Consolidated Ry., El. Lt. & Equip. Co.

Maximum Battery Temperature Allowable.

What is the maximum temperature at which lead storage batteries can safely be operated?—C. J. Causland, Ch. Elec. Penn. R. R., Chicago.

To the Editor:

There is no fixed point below which it can be said that the battery is not injured and above which it is injured. High temperatures tend to produce sulphation and the higher the temperature the greater the tendency to sulphate. A limit of 110 deg. has been established, not so much from the actual requirements of battery operation but more from a case of necessity under summer conditions. A battery operated at even 90 or 95 deg. continuously will tend to sulphate more readily than a battery operated at lower temperatures.

H. M. Beck, Electric Storage Battery Co.

Cadmium Readings in Battery Testing.

Should cadmium readings be taken on every battery when it is given its capacity test at cleaning periods?—Edward Wray.

To the Editor:

Cadmium readings as a general proposition are apt to be misleading and in railway car lighting practice should only be taken when the elements need renewing. Even then the physical appearance of the plates as a rule will give more reliable information to the experienced man than will the cadmium test. So that even when plates do need renewing, cadmium readings are not generally essential.

H. M. Beck, Electric Storage Battery Co.

Effect of Temperature on Constant Potential Charging.

We know that when a battery is charged at a constant current rate it will require a much higher voltage at the end of charge, when the temperature of the battery is low than when this same battery with the same condition of plates and electrolyte is at normal or warm temperature. In other words, the voltage to which the battery rises at the end of charge at constant current is a function of the temperature.

How will a constant potential battery charging system be affected by similar changes in temperature? In other words, will it be necessary to change the constant potential setting of the regulator slightly to correspond with the seasons of the year?—J. E. Gardner, Elec. Engr., C. B. & Q. R. R.

To the Editor:

If a storage battery is placed on a constant potential circuit it will take less charging current if the battery is at a low temperature than it will when the same battery is at normal temperature. Accordingly we would be lead to expect that a storage battery operated on a constant potential car lighting system would at least charge somewhat slower in the winter time than in the summer time.

Practical experience covering over 18 months' operation of such an equipment, however, has demonstrated that a constant potential of 2.25 volts per cell (Manchester positive and box negatives) will keep the battery in a fully charged condition even in the coldest winter months and will not over-charge it in the warm summer months. It should be stated, however, that the equipment on this particular run, from Chicago to Los Angeles, even in the winter time receives a certain amount of warm temperature charge every trip.

H. M. Beck, Electric Storage Battery Co.

Rejuvenation of Sulphated Cells.

Is the caustic soda method of treating sulphate cells of any real value?—J. W. Mercer, Adams & Westlake Co.

To the Editor:

This method of rejuvenation has been carefully investigated in our laboratory, in which badly sulphated cells from the same battery have been treated, some of the cells by the caustic soda method and some by the standard method of using a very weak sulphuric acid or clear water as electrolyte. In each case the cells to be rejuvenated have been charged in series and it has always been found that the cells given the regular treatment with very weak acid recovered just as soon as the plates given the caustic soda treatment.

As the sulphate is reduced, sulphuric acid will be liberated in the electrolyte and this, of course, must be replaced by plain water, where the old method is followed, in order to keep the electrolyte from becoming too strong during the treatment of the plates.

H. M. Beck, Electric Storage Battery Co.

Practical Stunts

We Pay a Dollar Apiece for Practical Stunts—Send in Your Ideas

Locating Polarity of Train Lines without Voltmeter.

To test out a train line connector head without a voltmeter is easy if you have a test lamp and some lamp cord. Connect one terminal on the regulator panel to positive battery; touch the left hand contact on the connector head (standing facing the end of the car) with the other end, and if you get a light the head is not reversed as the lamp will be connected from positive battery to negative battery. The positive side of the head can be tested in the same way. To test the head at the opposite end of the car, use the neutral wire or run a wire through the car.—W. M. Wiggins.

Rubber Jar Breakage Due to Insulators.

We have had considerable breakage of rubber jars in our car lighting batteries, due to the side insulator being jammed against the trays with the jerking of the train where insulators are placed midway between the corners of the tray. A good way to overcome this is to put the insulator out flush with the end of the tray, thereby putting the pressure on the end of the grate and corner of the jar instead of the sideboard and thin side of the jar. This will greatly reduce jar breakage from this source.—C. R. Alexander.

Undercutting Mica.

Referring to the Practical Stunt on "Commutator Slotting" by Robert Downie in the March issue of the *Railway Electrical Engineer*, I would say I have found it of much benefit to under cut mica in all classes of motor and generator service, especially where the commutator speed is high, as with turbo generators. I generally use a three-cornered file with the point mroken off about ½ an inch. Cutting is carefully done by hand until the mica is about $\frac{3}{32}$ of an inch below the copper surface.

A very important thing to remember in the care of the commutator is that it must be kept perfectly dry and a good grade of brushes should always be used. After turning down or sand-papering the surface of the commutator it gets to be a chocolate brown with about two or three days' service and this color always indicates a good condition of the commutator. Do not lubricate an undercut commutator and do not sand-paper it very often.—J. G. Koppel.

Field Fuse Trouble.

I ran across a case of trouble recently which puzzled me for some time, and although it was a simple thing when finally discovered, it caused me sufficient worry to believe that it will interest other car lighting men who may be some day up against a similar problem.

I found that the axle equipment would operate O. K. for a short time after the automatic switch closed, but when the voltage rose above 34 volts the field fuse would blow. I finally found that the connection at the generator of positive generator and positive field leads were reversed, that is, the field lead was connected to positive generator and the positive generator lead to positive field.

This trouble would easily have been found if the equipment had been motored in the yard before leaving, for the field fuse would then blow just as soon as the automatic switch was closed, since it is then connected directly in the armature circuit. This is the easiest and quickest way of locating such a case of trouble.

Hugh G. Hobson,
Ludlow, Ky.

Team Work

A crew of men working under a full head of steam for half a day will accomplish more than the same crew working at half-power for a full day. Because they will waste less time in overcoming their own inertia.

* *

I saw this illustrated out in the piney woods the other day by a crew of men who had been told they could go hunting in the afternoon if they got their quota of logs before noon. Did they do it?

* *

They overshot the mark by several thousand feet, every log handled in perfect shape and well and safely loaded. How did they do it?

* *

By team work. Every man throughout the job knew that his own pals would knock his insignificant block off if he didn't do his darndest every minute. And here's the big point about the experiment: Every man in the bunch enjoyed that morning's smoothly and swiftly running work more than a month of ordinary dragging, drooling, waiting-for-the-whistle.

* *

But who hasn't seen a crew of men working against time to gain some pet project—the defeat of a rival crew, an early knock-off for a special purpose, or some such thing? And who hasn't been struck by the happy, good-humored way they went about their work, working all together and each to his limit, yet finding a little superfluous energy to extend in gentle joshing of one another—and of the rival crew if within hailing distance?

* *

Tell you what, people; come to consider it carefully and we find that it always happens just that way. The fellow who enjoys his work is the man who works at it as if he enjoyed it, who takes pride in doing it as swiftly and as well as in him lies power to do.

Your doddering timekiller has a heleva time through life when you bring the right focus to bear on him. He spends nearly half his life going to, at, or coming from his daily task, and two-thirds of all the balance in bed. If then, he shirks his job and hates it, keeping both eyes eternally upon the clock, he is living just one-sixth part of a life—and even that part such a man is sure to waste in loafing trivialties of no real benefit to himself or the rest of the race.

* *

The man who takes his daily task as a long slavery leading up to a few hours of license is swindling himself out of all his real-joy-in-life and slowly suiciding at the same time.

* *

This last because Nature always takes away from her children what they misuse or do not use at all.

* *

Get happy in your work, friend, or get work you can find happiness in.

* *

The man who dedicates himself to a life of hateful toil is no hero, but a fool both from his own standpoint and from that of Nature. Nature wants her work done well or done over—that's why progress is so slow.

* *

Even the willing worker will slip now and again and spoil his work; but he places the blame as he creates the praise and so goes back over it cheerfully, knowing that, after all, it is his work, his very own.

* *

The unwilling worker, on the other hand, works only under the lash of stern necessity; thereby admitting himself to be a Slave and not a Man.

—From "Steam Machinery."

With the Manufacturers

Semi-Indirect Lighting in Railway Cars

There is a psychological effect of increased warmth and comfort produced by an open fire-place even though the temperature is no greater than when the source of heat is not visible. A similar effect is produced in artificial lighting. Where the source of light is invisible with too great uniformity in light distribution with the consequent obliteration of shades and shadows, the effect is less pleasing and less comfortable than when the source of light is partly visible. Semi-indirect lighting has many adherents who cite this condition as an argument in its favor over the totally indirect lighting. There have been a number of designs developed using the principle of semi-indirect lighting, and several of these types are in use on railway cars. There is a certain similarity in the appearance which does not detract from usefulness, but we nevertheless welcome a departure if the change in design is not made at a sacrifice to the quality of the lighting.

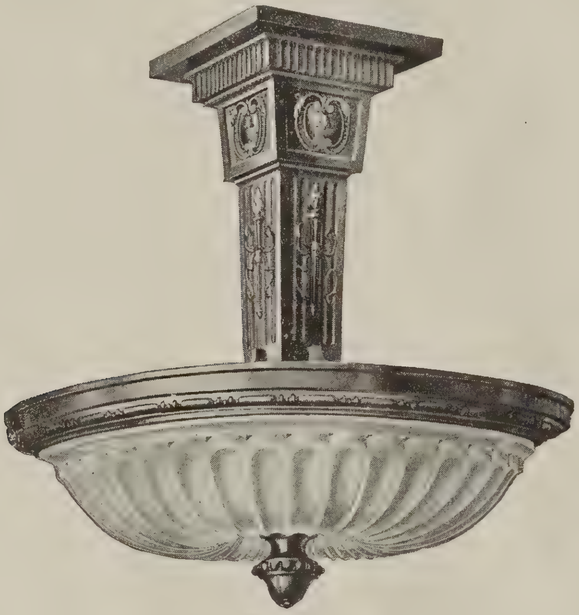


Fig. 165. New Semi-Indirect Lighting Fixture for Railway Cars.

The Safety Car Heating and Lighting Company has recently developed a new type of semi-indirect lighting fixture which is illustrated herewith. This fixture is a pleasing innovation in design, and in construction has a number of meritorious features. The base and stem of the fixture, as is true of all semi-indirect lighting fixtures, are the portions most brilliantly illuminated, and obviously the parts most noticeable. The base and supporting stem of this fixture is well proportioned and of a pleasing design. The construction of the fixture is not entirely dependent on the metal knob used at the bottom of the bowl, but this feature of the design presents a pleasing contrast to the usual bowl and creates an impression of visible support.

The glass bowl is so designed as to utilize the maximum light reflected to the ceiling to the best advantage. Four 25-watt lamps are used in this fixture, with the resulting absence of shadows cast by the arms of the fixture on the ceiling, which is a defect frequently noticed in some types of semi-indirect and totally indirect lighting fixtures. The bowl of this fixture is supported by a hinge and catch so that the glassware can be easily cleaned. The bowl is a light density opal of a type that transmits much light without producing objectionable glare.

"D. & W." Oil Fuse Cutouts

The satisfactory fusing of large capacity transformers and branch lines is a problem which nearly all railroads and power companies have found difficult to solve. The porcelain plug cutout which is commonly used is found to be very unsatisfactory when fused above 15 or 20 amperes. In the majority of cases this device is destroyed, especially when blown on circuit of low power factor. This necessitates the replacing of the entire cutout.

Furthermore the unreliability of the enclosed fuse, except in small capacities, in high tension service of 2,000 volts or more, has brought it very generally into discredit. The cause of the uncertainty of operation was unknown until it was discovered that the porous filling, used in these devices to suppress the arc, became a conductor under certain conditions of elevation of temperature; and its effectiveness as an arc suppressing material was thereby entirely destroyed. This phenomenon has been termed the "Nernst effect."

Exhaustive investigations have shown that any one of the materials suitable for use as a porous filling was affected in like manner. From this discovery it became apparent that some radical change in fuse design must be made in order to produce a protective device for high tension circuits, which would be reliable.

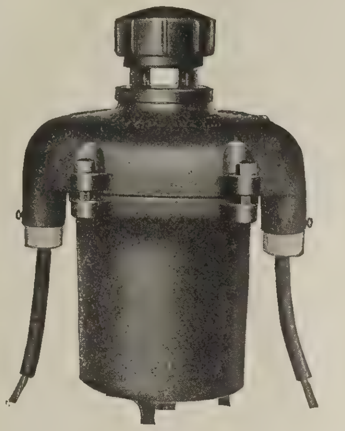
A careful study of the whole problem has led to the production of the "D. & W." oil break fuse box, which possesses many advantages over any type of primary cutout heretofore used. In this cutout, the fusible element is placed under a heavy body of special oil. On the blowing of the fuse the terminals are so arranged that they are forcibly thrown apart and the oil being interposed between them, effectually prevents the formation of an arc. Exhaustive tests have been made under abnormally exacting conditions of large generator capacity and low power factor, and its operation has been so perfect as to prove beyond question its value as a protective device. A large number of these cutouts have been in commercial operation for over a year, where they have given universal satisfaction. The cutout is provided with an effective venting system which prevents any accumulation of pressure within the casing and also the blowing out of any considerable quantity of oil.

The oil container is provided with a plug outlet at the bottom which permits the drawing off of the oil when on rare occasions this becomes necessary. A very simple oil filter can be supplied which will readily remove any carbon or similar impurities, so that the oil from the installation of these cutouts may be readily used over and over again. Under ordinary conditions of service the oil would not require drawing off more than once in a year or two for such purification.

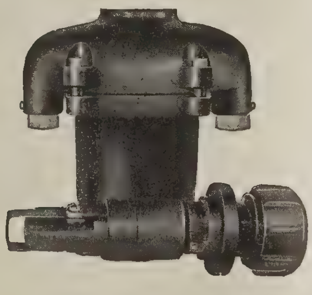
At the present time there are three capacities of cutouts on the market for overhead line construction, of 50, 100 and 200 ampere, 2500 volt capacity. Small capacity fuses for each size can be supplied.

The fuse links themselves are made from a carefully prepared, special alloy of low melting point and high conductivity. This is necessary in order to prevent abnormal rise in temperature of the oil, for unless this were done, carbonization would rapidly set in and destroy the effectiveness of this material.

Showing Method of Removing Fusable Element.



Oil Fuse Cutout.



Fusable Element Removed.

It will, of course, be realized that a protective device of this nature, in order to be commercially practicable, is limited as to its dimensions and consequently its overload capacity. In the design of these cutouts the safe operative point is limited to ten times the full load values; thus, the 50 ampere cutout, will safely handle 500 amperes, the 100 ampere cutout 1,000 amperes, and the 200 ampere 2,000 amperes on short circuit. Beyond that is an ample safety factor, so that these devices are suitable for all ordinary conditions of commercial service.

Special precaution have been taken to so design the device as to render re-fusing safe for the operator. A lineman can insert a new fuse even when the line is short-circuited, without risk to himself, as the whole device is effectually locked against the blowing out of the carrier and the oil, in case of the unexpected blowing of a fuse during the operation of fuse renewal. This is effected by arranging for automatically locking the cover before contact is made with the fuse terminals. The fusible element is light and readily inserted, and the linemen can carry a number of them in their cases without inconvenience and at slight expense.

The cutout is not intended for use as a switching device. It can, however, be depended upon to open moderate loads when used in this manner, but it is not recommended for that purpose.

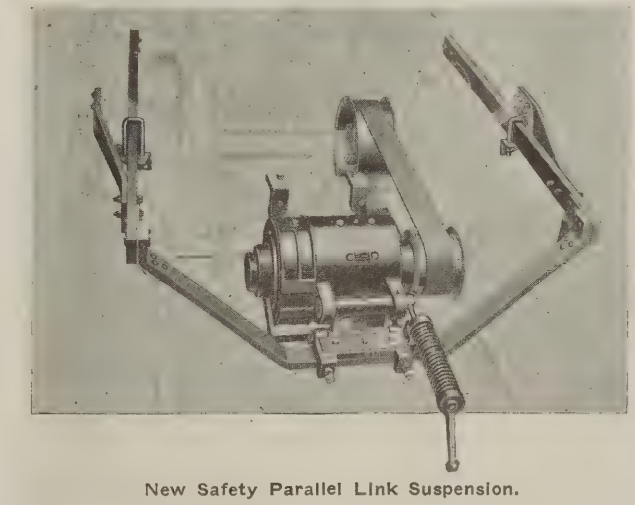
There is now in preparation three phase types for subway service and similar designs for higher potentials up to 13,000 volts, which will shortly be on the market.

New "Safety" Generator Suspension

Simplicity and strength with accessibility to the operating parts of the generator combined with constant belt tension are the principal features necessary in a well-designed generator suspension. The Safety Car Heating and Lighting Company has given this part of its axle-lighting equipment careful study, resulting in the type of suspension pictured in the illustration. The principle is that of a parallel suspension with the points of support below the dynamo.

The dynamo frame has four lugs, cast as an integral part. These lugs are drilled for supporting shafts which pass through the lugs and through a solid link, which totally fills the distance between the lugs to prevent lateral motion. The lower ends of the links are supported by shafts which pass through the links and the supporting frame. Since the shafts are rigidly locked in the lugs of the dynamo and the supporting frame, the turning motion is wholly on the shafts and no wear occurs in the dynamo lugs or supporting frame.

The tension spring bracket is bolted to the supporting frame and the tension rod is secured to the end of the upper outside shaft; the pull of the tension spring tending to pull the dynamo in a direction away from the truck. The tension rod is threaded just the right amount to give the proper belt tension when the tension nut is screwed up as far as it will go. When the links are in a vertical position, the belt tension is derived from the pull of the spring. If the belt is of such a length that the links are inclined away from the truck, the weight of the dynamo tends to increase the belt tension, but at the same time the compression of the spring has been lessened. This spring is so designed that the loss of compression is equalized by the additional weight of the dynamo, and constant belt tension is maintained throughout the limits of the swing on the links. If the links incline towards the truck, the weight is subtracted from the compression of the spring, and the belt tension is still maintained at a constant value.



New Safety Parallel Link Suspension.

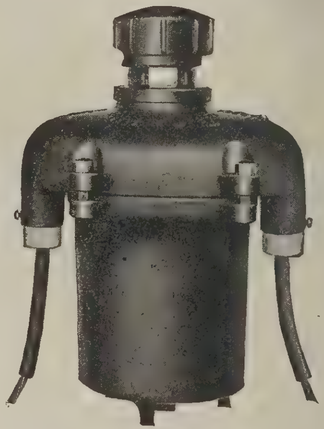
Exhibit of "The

Our exhibit in Space No. 331 at the Master Mechanics and Master
equipment---it is typical of the special service we maintain for rail
both semi-indirect and direct; Special car type Diehl fans; Okonite
and shop lighting; "D & W" fuses and cutouts; Deltabeston wire
necessary in railroad service. These are but a small part of all the

For Car Lighting

The soft warm tones of the semi-indirect lighting fixtures are very pleasing to the eye. Pictured above is one of our many new types of semi-indirect car lighting units. These with many other types of car lighting fixtures are shown in our exhibit, space No. 331, as well as fixtures for office lighting.

"D & W"
Oil Fuse Cut-outs



Designed to eliminate the burnouts of the ordinary enclosed fuse on high tension circuits. Fuses immersed in oil may be replaced with complete safety by linemen, automatic lockout prevents fuses being cut in circuit until cover is closed, oil easily drawn off and renewed.

Central Elect

The House

320-326 S. Fifth Ave.

House of Service"

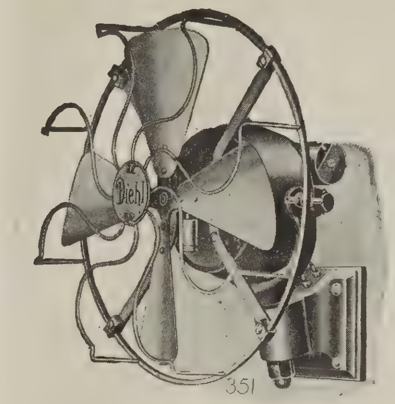
Car Builders Conventions shows a section of a car with electrical roads. Here are shown several new types of car lighting fixtures Wires and Cables; Colombia Lamps for car lighting, station, yard for headlight armatures, and many other electrical accessories so equipment we supply---if it's electrical we can furnish it.

OKONITE

TRADE MARK.

Insulated wire for railway signals, car lighting and power service must be absolutely dependable and have the highest insulating qualities. For years Okonite has been the standard insulation in railroad service. Okonite Insulation contains never less than 30% dry, fine, up-river Para rubber and is made in but **one grade only—THE BEST.**

Diehl Car Fans



give a finishing touch to passenger comfort. Designed specially to meet the severe conditions of this service. The fan body is readily removed from the base without disturbing the wiring. Pleasing in design.

ric Company
of Service

Chicago

These features of constant belt tension and the limit of the amount of belt tension obtainable are very important in that they eliminate excessive belt strain, but at the same time compensate for stretching of the belt and prevent belt slipping.

All parts of the suspension which are subjected to wear are lubricated, grease pockets with felt retaining washers being provided to retain the grease, and all parts coming in contact with the suspension irons are protected by wearing plates.

The arrangement for lining up the dynamo is simple and easily operated. A supporting frame is screwed to the suspension irons by means of six bolts, the center one on the front side passing through a round hole in the supporting frame and the suspension iron. The holes in the supporting frame for the other five bolts are slotted so that the whole frame can be rotated around the first mentioned bolt. To line up the dynamo it is only necessary to loosen all the nuts, and then either tighten or loosen two adjusting bolts, which pass through lugs on the supporting frame and bear against the side of the suspension irons. When the dynamo is properly lined up, it is securely locked in position by tightening the six nuts.

The absence of long supporting bars gives a clear space around the dynamo, allowing ample room for inspection of the dynamo and for the removal of the pulley, heads and armature, if necessary.

As all the working parts of the suspension are assembled complete with the generator before shipment, the proper operation is not dependent upon the assembly on the truck by the car builder. The supporting frame is supported by a type of suspension irons best suited to the truck used. In the illustration, one side is supported by a cross member riveted to the side irons, while the other side is held by a bracket bolted directly to the end sill of the truck. By this arrangement, only half the weight is carried by the side irons.

New Anderson Plugs and Receptacles

Several noteworthy improvements have been made recently in the A. R. E. E. standard charging plugs and receptacles as well as in telephone plugs and receptacles for car use by the Albert & J. M. Anderson Mfg. Company. The improved type "C" battery charging receptacle is provided with an iron guide ring located in front of the contact cylinders and this ring takes all the weight of the plug and cable, thus preventing any strain or damage to the copper spring contacts such as might be experienced when the car is moved without withdrawing the plug, or from any other strain put on the plug or cable. This also holds the plug solidly in position and prevents arcing and burning at the contacts. This receptacle is also provided with a new style of spring lid, which is positive in its closing. The design of the lugs on this receptacle are such as make it easy to solder the wire in same after the receptacle has been mounted upon the car; these lugs are then securely fastned in the receptacle. The new receptacle for car mounting is made so that the housing will fit the old style brackets which have been installed in car lighting service for some time.

Improved Type A Plug.

Improved Type C for Car Mounting.

The switchboard and yard charging type receptacles also have similar improvements which adds to their life and insures more reliable service.

Type R for Yard Use.

The Type "A" plug has also been improved as to connection and an iron handle is furnished with a cable clamp to take the strain off the lugs. This clamp also prevents the cable chafing and breaking at the entrance to the handle. The type "A" plug with standard Aetna handle is recommended for switchboard charging and the iron handle for yard charging.

Ideal Lighting Bulletin.

The Central Electric Company has just issued a new bulletin entitled "Ideal Lighting," which describes and illustrates the various types of "Alexalite" indirect fixtures.

There are a great diversity of types of this unit designed to meet the various requirements of size and decorative features. The designs include plain commercial, moderately decorative and full decorative types, and from the many designs of the latter class it will be possible to match practically any decorative scheme desired. There are in all 18 different types of Alexalites which will accommodate the new type "C" high efficiency nitrogen filled mazda lamps. Numerous photographs of installations of indirect lights are shown with testimonial letters regarding each.

Big Installation of Dossert Connectors.

Dossert & Company advised recently of a big order for solderless connectors to be used at the new Union and Calvert stations of the Penn. R. R. in Baltimore. The connectors are for manhole junctions and are of various types, mostly cable taps, and are for conductors ranging from 700,000 c.m. to No. 2 solid wire.

RAILWAY
ELECTRICAL ENGINEER

Official Journal
of the Association of Railway Electrical Engineers.
PUBLISHED MONTHLY BY
WRAY PUBLISHING CO.
EDWARD WRAY,
President.
800 ADVERTISING BLDG.—123 W. MADISON ST.
CHICAGO.
Telephone, Randolph 7414.

Entered as second-class matter, August 6, 1909, at the Post Office at Chicago, Ill , under the Act of March 3, 1879.

TERMS OF SUBSCRIPTION
United States, Canada and Mexico . . . Per Year, $1.00
Foreign ....Per Year, $1.50

OUR OBJECT.

The object of this publication is to provide a medium for the free interchange of ideas and experience among those identified with the operation of electrical apparatus as applied to railway practice.

In this mutual exchange of ideas among the men prominent in the field there will result a better understanding and solution of the problems before us and a wonderful inspiration for all to greater achievements.

CONTENTS

Page
Editorial:
The Master Mechanics and Electrification............ 37
Yard Lighting 37
Semi-Annual Convention of A. R. E. E., Atlantic City, N. J., June 12th, 1914, Reports of the Committees.. 38
Group at the Semi-Annual Convention.................. 39
M. C. B. Committee on Train Lighting.................. 43
A. R. M. M. Committee on Locomotive Headlights...... 44
Exhibits of Interest to Electrical Men.................. 46
Magnetic Properties of Electrolytic Iron Melted in Vacuo 48
Track Scale and Yard Lighting—H. Kirschberg and A. C. Cotton 49
The Lead Storage Battery in Railway Car Lighting and Signal Work—H. M. Beck........................ 53
Penn. R. R. School of Electricity, Lesson No. 14, Mathematics, Whole Numbers.......................... 56
Railroad Electricians' Club—Review Lesson on Ohm's Law 59
A. B. C. Car Lighting Course, Lesson No. 30, American Headlight, Model "D"........................... 61
Prize Question Box.................................... 65
Practical Stunts 66
L. R. Pomeroy.. 67
E. S. B. Car Lighting System........................ 67
New Single Rope Automatic Cut-Out Lamp Hanger...... 68
Association Directory 68

The Master Mechanics and Electrification

Another testimonial to the fact that railroad electrification is with us and has come to stay is found in the action taken at the recent A. R. M. M. convention at Atlantic City. It was decided at this time that there should be a standing committee on this subject which will report on conditions annually because, as stated by its committee on subjects, it "believes that the Master Mechanics' Association should keep closely in touch with the question of electric operation, with the idea that it is impossible to predict where or when electrification of steam railroads may be introduced."

The action is unquestionably a far-sighted and a very wise one and because of the high standing of the A. R. M. M., which is one of the oldest and most influential of all technical societies, its action calls attention to the vital importance of the general subject of electricity in railroad practice. Not only does this apply to railroad electrification which, although at the present time occupies the center of the stage of public and technical interest, but also the innumerable applications of electricity in railroad practice in shops, stations, train lighting, yards, terminals, etc., which even aside from matters of electrification, should command special consideration. The investment in electrical equipment on railroads at the present time will run into several hundred million dollars, in spite of the fact that only three-fourths of one per cent of the present railroad mileage is electrified.

Various committees of the Association of Railway Electric Engineers have given consideration to these subjects for the past six years and have actively cooperated with similar committees of the A. R. M. M. and M. C. B. Associations. Last year a special committee on electric traction was appointed, the personnel of which includes many men of wide experience in this subject. A preliminary report of this committee is given in another part of this issue.

The final report of this committee will include both a technical consideration of the principles involved, a discussion of equipment in operation both in U. S. and abroad, and much detail data in regard to operation of existing electrifications. The acitivities of this committee as well as the similar committee of the M. M. Association will be watched with great deal of interest.

Yard Lighting

With the recent development of the high efficiency nitrogen filled mazda lamps it now becomes possible to economically illuminate railroad yards, terminals, etc., so this subject is to be given special consideration by the committee on illumination of the A. R. E. E.

The practice in the past for laying out a new classification yard or railway terminal has been to make the track layout first, with no provision whatsoever for poles for lighting units, so that when this subject was then put up to the electrical engineer to work out suitable lighting system, it has been necessary to place the lamps on poles at the edge of the trackage where more than half of the light would be wasted, or it has been necessary to mount the lamps on a long span wire with its attendant difficulties of maintenance and lead wires.

With the great economy of the new lamps, giving over two candlepower per watt, as well as the great flexibility of system obtainable in the use of either high power 750-watt or 1,000-watt units or with the low power series lighting units, the yard can be illuminated either by general illumination from large units mounted high or from small series units mounted low in rows between each second pair of tracks.

As outlined in an article on this subject in another part of this issue, the track scale and classification yard of a division oftentimes becomes the point of greatest congestion, so that high efficiency at this point means higher efficiency for the entire system. There is probably no one factor that will so work for high efficiency here as an effective system of yard lighting.

Semi-Annual Convention

Association of Railway Electrical Engineers, Atlantic City, N. J., June 12, 1914

Meeting was called to order by Vice-President Jansen, and report of the secretary-treasurer read and accepted. Secretary Andreucetti spoke of the need of an active campaign for new members and outlined a plan to be followed during the summer and fall.

The report of the Committee on Axle Equipment, as published in the June issue of the *Railway Electrical Engineer,* was then read by Mr. L. S. Billau, B. & O. R. R.

Committee on Data and Information.

The report of this committee was then read by Edward Wray, chairman, in which was outlined a set of tabulated information to be requested from motive power officials of the various roads of which the following is a brief condensed outline:

Rolling Equipment.

(1) Car lighting data: Give number of cars electric lighted, etc., continue the work in this line of previous committees.
(2) Car lighting costs: For various types of cars, methods of keeping cost, etc.
(3) Car lighting belts: Mileage and methods of accounting.
(4) Water for batteries: What kind used at various points.
(5) Motor cars: Number of various types of cars in service.
(6) Industrial trucks: Number of trucks, freight, baggage, commissary, etc., also operating costs.
(7) Electric headlights: Committee reserved judgment until learning of report of Committee of Master Mechanics' Association.

Shop and Station Equipment.

(1) Lamps: Number of large lamps of various types in use for lighting shops, stations, yards, etc.
(2) Shop motors: The total horsepower, a. c. and d. c.
(3) Generators: Total kw. a. c. and kw. d. c.
(4) Number of shops: With motor horsepower and stating whether power is generated or purchased.
(5) Number, type and motor horsepower of transfer and turntables.
(6) Locomotive cranes: Number, capacity and motor horsepower.

It was suggested by Mr. Jansen that the data be requested as of July 1, 1914, as this is the end of the fiscal year for most railroads. Mr. Wray stated that it was his intention to have these questions printed in blank form, which would make the returns of a uniform and complete nature.

Committee on Electric Traction.

Mr. J. H. Davis, B. & O. R. R., then read the report of the Committee on Electric Traction, as follows:

"This committee was appointed the latter part of 1913, and will submit a report at the convention to be held in Chicago during October, 1914. The committee has held several meetings and the scope and various divisions of the report have been discussed by correspondence. On account of the broad geographical area covered by the committee, most of the report work will have to be done by correspondence.

We are fortunate in having one member of this committee now located in Switzerland who will be in position to give us a close-range description of the European electrifications, and we hope to obtain from him some interesting data on costs of electrification in those countries. As this member has been closely associated with electrification work on a trunk line railroad in the United States for a number of years, his viewpoint should be particularly valuable, and we can feel assured that any operating figures which he obtains will be on a similar basis with American costs.

E. W. Jansen (I. C. R. R.), L. S. Billau (B. & O. R. R.), & J. A. Andreucetti (C. & N. W. R. R.), Sec. Treas. of A. R. E. E. on the Exhibit Pier.

Up to the present time there have been about 20 steam railroad electrifications carried out, in most cases the former steam engine operation being replaced by electric traction, and in a few cases electrified extensions added to existing steam railroads. With few exceptions these electrifications have been brought about on account of tunnel operation, terminal necessities or suburban traffic, and were generally for a zone of moderate length.

At the present time electrification of railroads is entering upon a new and larger stage of development, that is the application to a full engine division or more of a trunk line railroad where unusually heavy traffic is to be handled. Some of the important systems now under consideration are the mountain divisions of the Canadian Pacific Railway and the Chicago, Milwaukee & Puget Sound Ry.; and a coal traffic division of the Norfolk & Western Ry. The Butte, Anaconda & Pacific Ry. is a unique case of electric traction—which has recently been placed in operation.

The electric systems used for the various railroads have been modified gradually and proceeding along to broad lines of direct or alternating current. At the present time the most favored systems, both direct and alternating current, have not been placed in service to any great extent but are being considered for all large electrifications under consideration.

Group Attending the A. R. E. E. Convention at Atlantic City, June 12.

Front Row from left to right—1. Major Azel Ames (Kerite Co.); 2. Warren Young (Kerite Co.); 3. Edward Wray (Railway Electrical Engineer); 4. Daniel Woodhead (Central Elec. Co.); 5. J. M. Lorenz (Central Elec. Co.); 6. Otto Hildebrand (Edison Stg. Battery Co.); 7. F. V. McGinness (Edison Stg. Battery Co.); 8. ; 9. H. G. Thompson (Edison Stg. Battery Co.); 10. W. H. Rolinson (Westinghouse Lamp Co.); 11. ; 12. L. B. Knight (B. & A. Ry.); 13. C. D. Axtell (D. L. & W. Ry.); 14. ; 15. Mr. Hale; 16.

Second Row from left to right—1. C. R. Sugg (A. C. L. Ry.); 2. George R. Berger (Gould Coupler Co.); 3. R. S. Carrick (Independent Lamp & Wire Co.); 4. C. W. Bender (Nat'l. Lamp Wks.); 5. A. E. Voigt (A., T. & S. F. Ry.); 6. W. E. Ballantine (Willard Stg. Battery Co.); 7. W. F. Bauer (Edison Stg. Battery Co.); 8. W. L. Bliss (U. S. L. & H. Co.); 9. Alex. McGary (N. Y. Central Lines); 10. E. W. Jansen (Illinois Central Ry.); 11. L. S. Billau (B. & O. Ry.); 12. D. J. Cartwright (Lehigh Valley Ry.); 13. H. C. Meloy (L. S. & M. S. Ry.); 14. J. A. Andreucetti (C. & N. W. Ry.); 15. A. B. Appler (D. & H. Ry.); 16. J. T. Everett (Southern Ry.); 17. H. E. Hunt (Elec. Stg. Battery Co.).

Third Row from left to right—1. F. J. White (Okonite Co.); 2. H. W. Leithold (Novelty Elec. Co.); 3. N. G. Stark (Oneida Steel Pulley Co.); 4. W. E. Fawcett (Main Belting Co.); 5. Ernst Waltman (A. & J. M. Anderson Mfg. Co.); 6. ; 7. ; 8. ; 9. T. L. Mount (Cons. R. E. L. & H. Co.); 10. ; 11. J. Lester Woodbridge (Elec. Stg. Battery Co.); 12. ; 13. ; 14. ; 15. George E. Hulse (Safety C. H. & Ltg. Co.); 16. Mr. Rogers (Penn. R. R.); 17. Norman D. MacDonald (Elec. Test. Labs.).

Fourth Row Center, left to right—1. Herman Will (The Bristol Co.); 2. E. E. Goddard (Penn. R. R.); 3. George W. Cravens (C. & C. Elec. Mfg. Co.); 4. F. S. Gassway (Willard Stg. Battery Co.); 5. J. L. Marsh (Safety C. H. & L. Co.); 6. W. H. Keirn (Penn. R. R.); 7. J. L. Hays, Westinghouse E. & M. Co.); 8. J. D. Brown (B. & O. R. R.).

Top Row, from left to right—1. M. J. Keifer (Crouse-Hinds Co.); 2. ; 3. W. R. Hungerford (Cons. R. E. L. & E. Co.); 4. ; 5. ; 6. E. G. Smith (Crouse-Hinds Co.); 7. ; 8. M. G. Hovey (Okonite Co.); 9. T. V. Buckwalter (Penn. R. R.); 10. E. L. Willson (Hazard Mfg. Co.); 11. J. R. Sloan (Penn. R. R.); 12. ; 13. J. J. Mallay (Safety C. H. & L. Co.); 14. J. A. Dixon (Safety C. H. & L. Co.); 15. L. Schepmoes (Safety C. H. & L. Co.); 16. J. A. Snell (Macbeth-Evans Glass Co.); 17. Frank Zimowski (N. Y., N. H. & H. Ry.); 18. J. H. Davis (B. & O. Ry.); 19. Percy Smith (Kerite Ins. Wire Co.).

(Copies of Photo can be obtained from Harper B. Smith, Photog., Board Walk, Atlantic City. Price, $0.50.)

The report will give a brief review and description of past electrifications together with the latest information on the several electrifications now under way. It will also give a description of the salient points of the various systems used for electric traction. The reasons which determine electrification and the results obtained will be outlined for the various conditions of traffic and facility of train movement. Another subject to be covered by the report will treat on the supply of power for electric traction, that is, whether it shall be generated primarily by the railroad or purchased.

As far as possible comparative costs and operating expenses for typical electrified lines will be given and compared with the costs under steam operation.

It will be seen that the above indicates a broad scope for this report and the several divisions will be covered to the best extent possible by the members of the committee as their time will permit."

Respectfully submitted,
H. M. Van Gelder, Chairman, Westinghouse, Church, Kerr & Co.
J. H. Davis, Elec. Engr., B. & O. R. R.
D. C. Woodbury, N. Y. C. & H. R. R. R.
Paul Real, Ass't Engr., N. Y., N. H. & H. R. R.
Chas. P. Kahler, Elec. Engr., Oregon Short Line R. R.
C. B. Keiser, M. M., Penna. Lines East.

Committee on Headend Equipment.

Secretary Andreucetti then read a progress report from Mr. K. R. Hare, Chairman, Northern Pacific R. R., in which the work of the committee was outlined. The report will be devoted largely to the construction and operation of the headend axle generator system with one 20 kw. generator or smaller size to furnish light for the entire train. The operating results obtained with this machine will be included in the committee's report.

Mr. Watson, H. C. Meloy (Lake Shore) and George H. Porter (Western Electric) on the Board Walk.

Another subject to be dealt with will be the relation between lamp load and battery capacity and the capacity of the axle generator under several typical conditions.

The report briefly described the "Bohan Train Lighter," which is a 20 kw. generator mounted on top of one truck of the baggage car so that it projects up through the floor of the car. This generator is driven by the Morse chain from a countershaft, which is in turn chain-driven from the forward axle of the forward truck. Clearance is provided between the floor and the machine and this is filled with a canvas to keep out dust and cold. An automatic lamp regulator will be provided.

The progress report of the committee was accepted.

Committee on Illumination.

Mr. L. S. Billau, chairman, B. & O. R. R., referred to the final report of the day coach lighting tests, which are now printed and ready for distribution. This report will be distributed to senior active members and copies can be obtained from Secretary Andreucetti at $1.00 each.

D. J. Cartwright (Lehigh Valley R. R.) Taking Life Easy in a Roller Chair.

In reference to the work to be undertaken by the committee, Mr. Billau said that in view of the radical developments in large incandescent lamps which are taking place at the present time, and which will render present installation of arc lamps obsolete, it has been decided to confine the efforts of the committee largely to question of yard illumination.

Committee on Specifications for Belting.

The report of this committee, as published in the June issue of the *Railway Electrical Engineer,* was then read by Mr. J. R. Sloan, chairman, Penn. R. R. Mr. L. S. Billau, B. & O. R. R., asked if these specifications had been used by any railroad as a basis for

Group of A. R. E. E. Delegates on the Hotel Dennis Lawn.

purchasing belting. Mr. Sloan replied that the Penn. R. R. had been purchasing its belting under these specifications for two years, except in regard to badge plate. The badge plate has been changed as it was found that it is impossible to keep track of the application and removal of belts. In reply to a question Mr. Sloan stated that probably 5 per cent of the belting purchased was rejected under these specifications for not meeting the various requirements. Report of the committee was accepted and referred to letter ballot.

L. C. Doane (Holophane Works), Mrs. L. Schepmoes (Safety C. H. & L. Co.), and Mr. L. Schepmoes (Also of the Safety Co.), on the Board Walk.

Committee on Loose Leaf Binders.

Mr. J. R. Sloan, chairman, Penn. R. R., read the report of the committee, from which it appeared that there are two sizes of sheets and two styles of binders which have been generally used, i. e., a 3 ring binder with sheet 4¼x7¼ in., and the sectional post binder with sheet 6x9 in. The first has been adopted by the Society of Automobile Engineers and the second by the American Electric Railway Association.

The committee recommended that the secretary be instructed to canvass the membership to ascertain how many holders are desired, make a contract for the number and sell same to the membership at cost, delivered to destination.

F. C. Beetem and H. E. Hunt (Electric Storage Battery Co.), W. F. Bower (Edison Storage Battery Co.), and T. L. Mount (Consolidated R. E. L. & E. Co.).

That the association furnish free of cost to all classes of membership one copy of each sheet as authorized by the Committee on Engineering Data.

That any member having engineering data that he believes sufficiently interesting to the membership to warrant printing ,forward same to the chairman of the Committee on Engineering Data.

That manufacturers supply information with respect to their product in this form and forward same to the membership.

After much discussion pro and con it was decided to adopt the 6x9 in. size, such as is used by the American Electric Railway Association.

Committee on Outside Construction and Yard Lighting.

This committee presented a preliminary report which dealt with the spacing, setting, dimensions and guying of poles and dealt very exhaustively with the subject of anchors, braces and ties. The pole fittings were then taken up and detail drawings of various fittings and hardware were shown. Under the subject of "Distribution" were covered overhead systems, arresters, secondary lines, conduit, manholes, cables, etc.

The report is a very comprehensive one, but as the committee expects to make several important changes in it when presented at the annual convention it will not be published complete until the final report is presented.

W. R. Hungerford and T. L. Mount (Consolidated Co.), and C. W. Bender (National Lamp Works).

Specifications for Overhead Wiring Crossings.

Mr. J. R. Sloan, chairman, Penn. R. R., stated that in accordance with the desire of the 1913 convention this committee had entered into correspondence with the Committee on Wire Crossings of the Association of Railway Telegraph Superintendents and had held a joint meeting with this committee. He explained in detail their objections to certain sections of the National Electric Light Association specifications, which have been adopted as standard by the Association of Railway Telegraph Superintendents. Apparently the objections raised were held as valid and the matter will probably be further considered by the Committee of Telegraph Association with a view to revising their specifications.

Mr. Sloan stated that an invitation had been extended by a special committee of the American Railway Association to attend a joint meeting on this subject.

Committee on Shop Practice.

Mr. George W. Cravens, chairman, C. & C. Electric Co., then outlined the work to be followed by this committee during the coming year and requested that members of the association supply information on the operation of electrically operated cranes, dynamic braking, electro magnets, etc.

"Okonite Jim" Lorenz (Central Electric Co.), on the Exhibit Pier.

Mr. L. S. Billau suggested that the committee take up the subject of cost of power for compressing air and referred to article by Mr. H. R. Bucks, of the Oregon Short Line, in the June issue of the *Railway Electrical Engineer*. He said that it is very evident that portable air tools must be supplanted by electric air tools and this subject should be thoroughly treated by the committee. Mr. Cravens said that the installation of small air-driven compressors instead of one central air compressor with the distribution pipes running throughout the shop would be considered in the committee report.

H. G. Thompson (Edison Storage Battery Co.).

Committee on Standards.

Mr. D. J. Cartwright, chairman, Lehigh Valley R. R., stated that all the members of this committee were also members of the M. C. B. Committee on Train Lighting and pointed out that the recommendations of this committee had been adopted by the M. C. B. committee and later accepted in the M. C. B. meeting and referred to letter ballot. These recommendations are published in another part of this issue.

The A. R. E. E. also recommended to the M. C. B. committee the following subjects for consideration:

(1) That means be provided by the manufacturers of car lighting equipment to attach supporting lugs on the generators so that any type of standard generator can be applied to any standard type of suspension.

(2) That some definite method be adopted to properly secure the battery box doors underneath the car.

Group on the Safety Booth Steps.

(3) That the truck builders be requested to submit drawings of trucks to the Committee on Standards of A. R. E. E. of such a design that a suitable suspension can be applied to the truck and afford clearances as called for by the M. C. B. association, using a 20 in. and 16 in. axle pulley with 11 in. and 8 in. generator pulleys respectively.

(4) That the truck builders be requested to submit drawings of brake beams to the committee on standards of the A. R. E. E. for both four and six-wheel trucks. Brake beams both inside and outside

W. L. Bliss, and H. A. Matthews (U. S. L. Co.).

hung, of such design that they will give ample belt clearance when using 20 in. and 16 in. axle pulley with 11 in. and 8 in. generator pulleys respectively.

In discussing the matter of supporting lugs on generators it was pointed out that there should be standard practice in this matter and that in order to find out what is the most desirable position to have the lugs and located on the generator both the railway men and manufacturers be canvassed by letter ballot.

Committee on Wire and Cable Specifications.

This report, as published in the June issue of the *Railway Electric Engineer,* was then read by Secretary Andreucetti. Report was then accepted as read.

Committee on Yard Facilities for Charging Batteries.

The work of this committee was outlined by Mr. D. B. Pastorius, chairman, Penn. R. R. He stated that it was the intention of the committee to consider the whole subject from the powerhouse to the storage battery, including wiring the yard, charging cables, battery houses, use of power trucks and the different emthods of charging storage batteries.

Mr. L. S. Billau, of the B. & O., suggested that the committee make recommendations as to the most suitable form of construction for yard charging cables to be presented possibly in the form of a specification. He also suggested that the committee report on the use of armoured cable for under construction in yards, etc.

Special Lamp Committee.

Mr. L. S. Billau, B. & O. R. R., then read the report of this committee, as published in the June issue of the *Railway Electrical Engineer,* and he pointed out that railroads are at the present time using train lighting lamps ranging from 10 watts to 100 watts in 10 watt steps. He urged that all railroads adhere to the lamps recommended for practice and eliminate as much as possible the use of those lamps which are not recommended.

Mr. Edward Wray then presented a paper on the "Ampere Hour Meter in Car Lighting Service," as published in the June issue of the *Railway Electrical Engineer.*

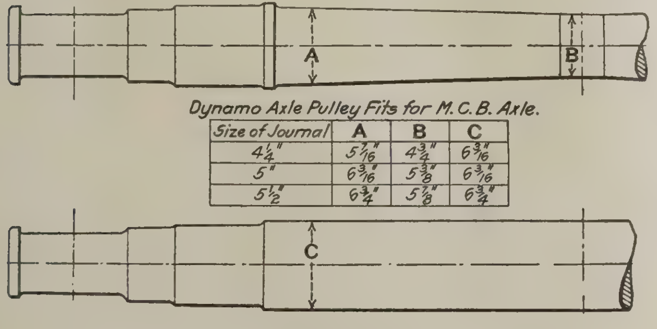
Upon motion the convention adjourned to re-convene in Chicago, October 24th to 30th, at the La Salle Hotel.

M. C. B. Committee on Train Lighting

In last year's report your committee recommended designs for standard pulley seats for application of axle pulleys, the designs being incorporated on exhibit showing M. C. B. standard 4¼ by 8 in. and 5 by 9 in. axles. This recommendation was rejected.

Your committee feels that most of the objections were due to the fact that the mechanical men of the railroads did not feel it desirable to operate with straight axles or axles with a straight pulley fit. However, there are a number of railroads which are using straight axles and axles with straight pulley fit, and, as stated by your committee last year, it was felt that a design of ale used on any road should meet the approval of the mechanical men of the road. Your committee's recommendation was with a view of standardizing the size of pulley seats for straight and tapered axles, thus making possible the use of interchangeable bushings, which will materially facilitate the handling of electric-lighted cars.

The extension of axle-lighting devices has demonstrated the necessity for standardizing the size of pulley seats not only from a standpoint of convenience in interchangeability, but from a standpoint of safety to equipment and economy in operation. Your committee is therefore still of the opinion that the association should approve as Recommended Practice the following:



Dynamo Axle Pulley Fits for M.C.B. Axle.

Size of Journal	A	B	C
4¼"	5 7/16"	4¾"	6 3/16"
5"	6 3/16"	5⅜"	6 3/16"
5½"	6¾"	5⅞"	6¾"

Exhibit "B."

Pulley Seats for Tapered or Straight Axles.

12. The dimensions of axles at the point of pulley fit shall be in accordance with the dimensions shown on Exhibit "B."

In last year's report your committee recommended standard dimensions for the inside of battery boxes. This recommendation was rejected on letter ballot, principally for the reason that the dimensions as given did not conform to the detail dimensions used by the various railroads. It was naturally impossible for the committee to recommend dimensions which would fit all of the standard battery boxes in existence, and it was the endeavor to recommend dimensions which represented the average practice of the roads. The committee feels that the M. C. B. Association should standardize the inside dimension of battery boxes for future construction, and again submit their recommendations to the M. C. B. Association as follows:

13. The inside clear dimension of battery boxes should be as follows:

Depth, front to back, 2 ft. 4 in.

Height in clear, not less than 21½ in.

Length of compartment for two standard double-compartment tanks or equivalent, 22⅝ in.

Length of compartment for four standard double-compartment tanks or equivalent, 3 ft. 9¼ in.

At last year's convention the committee recommended that the battery box tray be reinforced by safety angle irons or straps. This recommendation was not accepted on letter ballot, due to the fact that a number of the roads were of the opinion that a battery box properly designed for the weight it should carry and properly maintained had a sufficient factor of safety. Your committee feels that the liability of battery trays dropping down on the track is a sufficient hazard to justify the installation of safety irons or angles and again submit their recommendations as follows:

14. That in all battery-box designs, two angle irons or straps shall extend longitudinally under the battery box in such a location that in case of a defective battery-box floor the battery trays will be supported by the said angle irons or straps; the angle irons or straps shall be supported to the car body independent of the battery box proper and shall be of sufficient strength in all parts to safely support the battery in accordance with the weight shown in paragraph 8, and the additional weight of the battery box proper, and the angle irons or straps and the supports for same shall be so installed that they can be readily inspected for corrosion.

On Sheet U-9, Recommended Practice, adopted in 1912, is shown a G 18½ bulb with a base longer than the standard base. This was recommended in 1912 on account of the fact that the design of the fixtures in quite a number of car-lighting equipments was such as to require an extra length of base. The majority of roads owning such cars have modified their fixtures so as to accommodate the standard G 18½ bulb, and the committee recommends as follows:

15. The cut of the G 18½ bulb, as shown on Recommended Practice Sheet U-9, be changed in accordance with Exhibit "A."

Pulley Fit for Axle-Generator Shafts and Axle-Generator Pulleys.

Your committee has given considerable attention to the question of standard pulley fit for axle-generator shafts and standard generator pulleys. There are in service at present generator shafts with a variety of pulley fits, and also a large number of different designs of pulleys. These variations are the cause of an unnecessary expense in the maintenance of electric car-lighting apparatus, and with a view to standardizing these fixtures your committee would recommend that it be continued and that it be authorized to confer with a committee of manufacturers of car-lighting devices and a committee of the Association of Railway Electric Engineers, with a view to reaching final conclusions so that designs may be submitted to the association as a Recommended Practice.

Your committee recommends that items Nos. 12 and 13 be referred to letter ballot, and suggest that in voting on these questions the members of the association take into consideration the necessity of adopting for Recommended Practice the items as presented by the committee, and also the fact that it was impossible for the committee to make recommendations which would conform to the existing practice on all railroads, and their recommendations are based on their conclusions after going into the various subjects in detail, both as to the efficiency of the designs proposed and the question of obtaining standard equipment with the least possible change in present practice of the various roads considered.

If recommendations Nos. 12 and 13 are accepted, your committee recommends that they be inserted in the Recommended Practices as follows:

Item No. 12 should follow paragraph No. 22, revised number, as a separate paragraph with a paragraph number.

Item No. 13 should follow paragraph No. 18, revised number, under caption of batteries, and should have a separate paragraph number.

Respectfully submitted,
T. R. Cook, Chairman.
C. A. Brandt,
Ward Barnum,
D. J. Cartwright,
E. W. Jansen,
J. H. Davis,
C. H. Quinn,
Committee.

A. R. M. M. Committee on Locomotive Headlights

A very exhaustive report outlining the results of a series of tests made during 1913 was presented before the Railway Master Mechanics' Convention by their Committee on Locomotive Headlights. The tests included practically every type of headlight manufactured, tested both in the position of home light and opposing light. There was an average of over twenty men devoting their entire time to this investigation for five months last fall, in which Messrs. T. R. Cook, J. L. Minick, E. M. Fitz, all of the Pennsylvania Railroad, ably assisted in working out and managing the details of the tests.

In rating the headlights it was decided to assume as the reference plane the horizontal plane 3 ft. above the rail head of the locomotive, and to consider the intensity of the rays striking this plane at various points. All laboratory readings were taken normal to the ray in a vertical plane 25 ft. ahead of the focal center and perpendicular to the axis of the beam. Readings were taken at angles to correspond to stations in the reference plane 50, 100, 200, 300, 400, 500, 600, 700, 800, 900 and 1,000 ft. ahead of the focal center measured along the axis of the beam. Three points were taken for each station—one corresponding to the center of the track and one corresponding to 20 ft. each side of the center, the three points being in the same straight line at right angles to the axis of the beam.

These readings can be expressed either as the apparent candle-power of the beam directed at the given point in the reference plane or as the foot-candle illumination on an object at that point, due to an unrefleced source of light, at the location of the headlight, which would produce the same intensity of illumination at the given point.

Conclusions and Recommendations.

After going over the results of these tests in detail and after thorough discussion, the committee recommends as follows:

1. In order that a headlight shall be of such intensity as not to cause misreading of signals, obscuring of hand signals, fusees, red lanterns and classification lamps by opposing headlights, and be of such intensity as not to temporarily blind the engineman looking into same, a headlight must have an apparent beam candlepower, not greater than 3,000, referred to the center of the reference plane, from 500 to 1,000 ft. ahead of the locomotive.

2. In order that the engineman shall have sufficient illumination ahead of the engine to allow him to readily perform his duties while operating in and out of passenger terminals and industrial sidings, while switching in yard, and to readily locate whistle posts, yard limit and crossing signs and such other landmarks en route, a headlight, due to depreciation or to variations in the intensity of the source, must not at any time during service have apparent beam candle-power less than the following; the readings to be made in a vertical plane 25 ft. ahead of the focal center and referred to points at the various stations in the reference plane.

Readings at Center of Reference Plane.

Reading point ahead of focal center.	Apparent beam candle-power.
500 ft.	Not less than 450 c-p.
600 ft.	Not less than 490 c-p.
700 ft.	Not less than 500 c-p.
800 ft.	Not less than 500 c-p.
900 ft.	Not less than 500 c-p.
1 000 ft.	Not less than 500 c-p.

Average Side Readings (Average of Readings Taken at Each Station 20 ft. Each Side of the Center).

Reading point ahead of focal center.	Apparent beam candle-power.
50 ft.	Not less than 30 c-p.
100 ft.	Not less than 110 c-p.
200 ft.	Not less than 225 c-p.
300 ft.	Not less than 315 c-p.
400 ft.	Not less than 350 c-p.

The above readings are to be considered independent of the location of the headlight, the source and intensity of light, the design of the reflector, etc.

To design a headlight to meet the above requirements, the height of the headlight above the rail must be decided upon; then with a given kind of light, the design of reflector, the relative arrangement of reflector and source of light and the intensisy must be such that the readings will fall below the designated maximum with sufficient margin above the minimum requirements, that they will not at any time, during the depreciation of the source of light, reflector, etc., fall below the minimum requirements.

To further define the above maximum and minimum requirements, we show on Plate 1 a polar diagram of a headlight which at a height of 9 ft. 7 in. above the rail will give the maximum defined requirements, and on Plate 2 we show a polar diagram of a headlight which at a height of 9 ft. 7 in. above the rail will give the minimum defined requirements.

These polar diagrams were plotted from the average readings at the various angles to the axis of the reflector, and were made in a plane perpendicular to the axis of the reflector, at a distance of 25 ft. from the focal center, measured along the axis of the beam.

In general, it was found that the headlights of very high intensity, such as called for by some states whose laws require headlights of 1,500 unreflected candle-power, were actually dangerous.

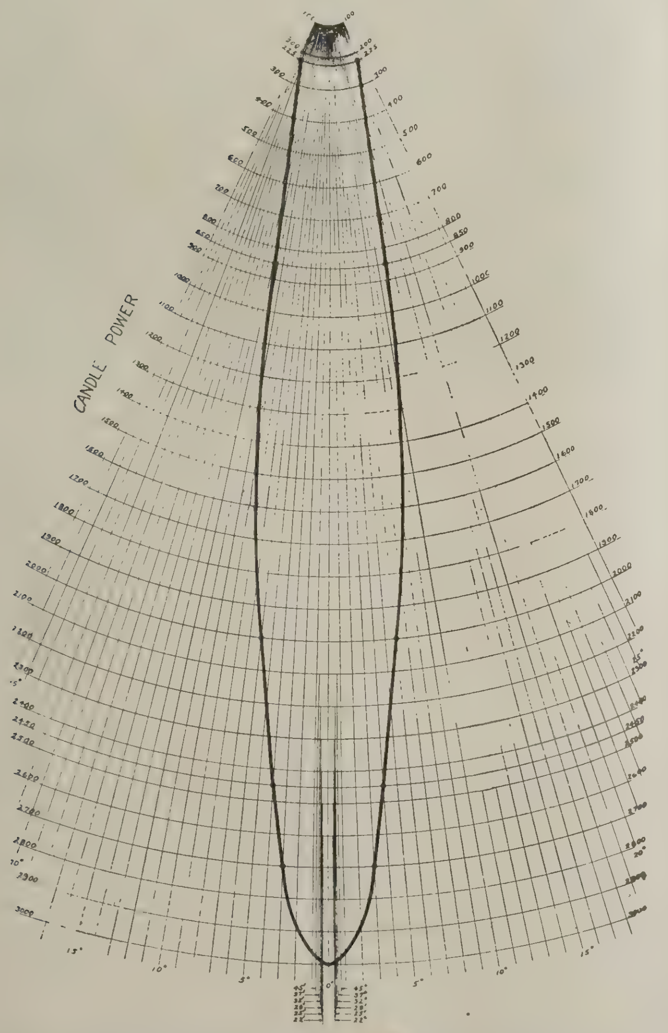


Plate I. Photometric Curve of a Headl[illegible]t Which Placed 9 ft. 7 In. Above Rail Will Give the Maxi[illegible]n Defined Requirements.

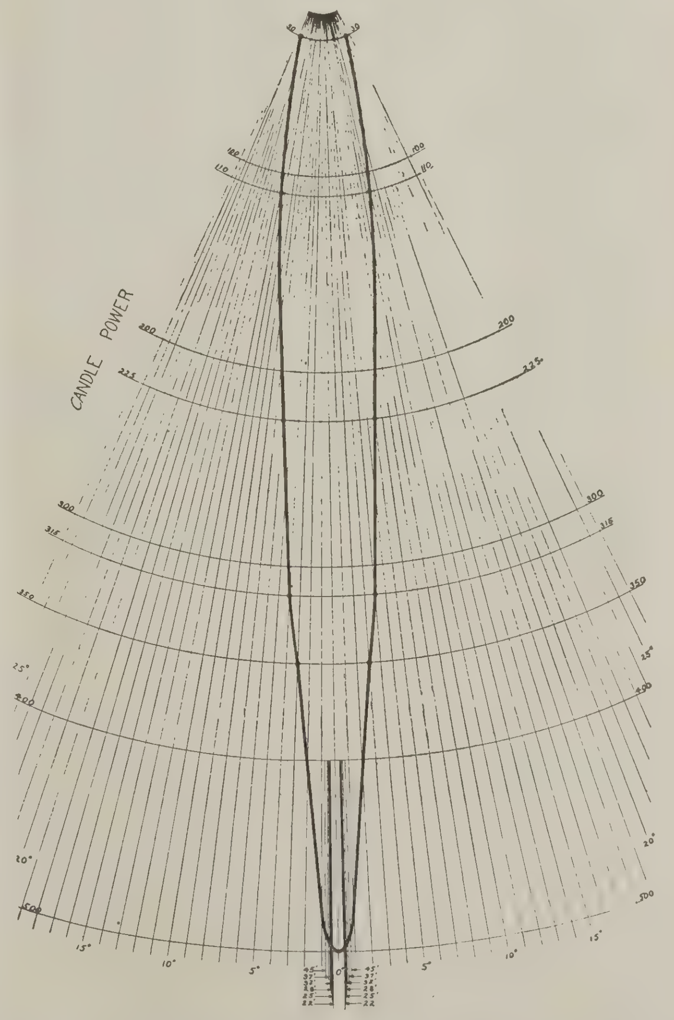


Plate II. Photometric Curve of a Headlight, Which, When Placed 9 ft. 7 In. Above Rail Will Give Minimum Defined Requirements.

Exhibits of Interest to Electrical Men

Central Electric Company exhibited a full section of a car, upon the ceiling of which were mounted several types of Alexalite indirect car lighting fixtures and also several types of semi-indirect fixtures. The "Daylite" concealed car lighting system, as described in the November, 1913, issue of the *Railway Electrical Engineer,* was also exhibited. On the car ceiling and walls were various types of Diehl fans, both the standard car fan, the special paddle fan and the exhaust fan. New Ralco plugs of various types were shown, as well as the new D. & W. fuse cut-out and numerous sizes of D. & W. fuses. A full assortment of Okonite wires was also exhibited. J. M. Lorenz and Daniel Woodhead were in charge of the exhibit.

Consolidated Ry. Elec. Ltg. & Equip. Co. had an operating exhibit of their axle car lighting system with the new type "L" regulator panel. This new panel is unique in that the ampere hour meter is employed to control the operation of the equipment. The ampere hour meter registers charge and discharge of the battery and when proper amount of charge has been given the battery the meter stops further charging, providing the voltage of the battery is up to a certain value. In other words, the voltage coil acts as a check on the operation of the meter. When the meter has operated so as to stop further charging, the battery floats on the line and the generator carries the load. At the next stop normal operation of the equipment is restored. This equipment will be described in detail in an early issue.

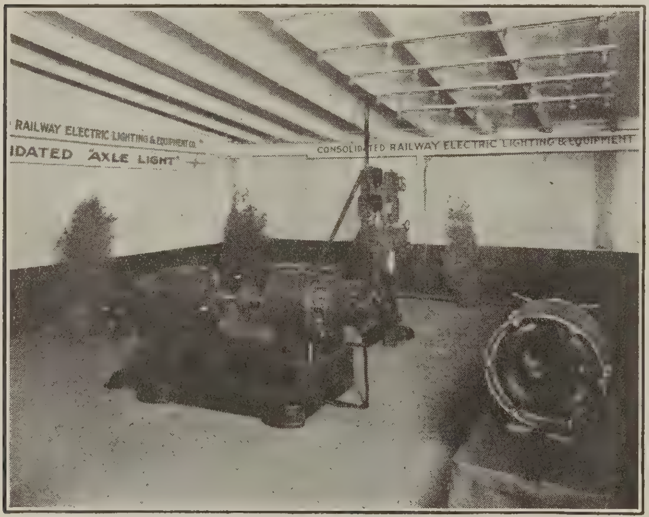

RAILWAY ELECTRIC LIGHTING & EQUIPMENT CO.
IDATED "AXLE LIGHT"
CONSOLIDATED RAILWAY ELECTRIC LIGHTING & EQUIPMENT

Exhibit of the Consolidated R. E. L. & E. Co.

A motor was employed to drive the standard type "D" generator at all the various speeds from zero to that corresponding to 90 miles an hour and a full set of lamps was provided in various circuits corresponding to those in the average car. Both a nickel-iron and a lead battery were installed and the switchboard was so wired that the car lighting equipment operated in connection with either battery, or the battery circuit could be entirely opened. It was shown that the new equipment operated equally well on Edison or lead battery without change of adjustment, and takes care of an open battery circuit condition without difficulty. Oneida Keystone axle pulley with bushing were also shown.

The company was represented at the Convention by Messrs. J. L. Watson, T. L. Mount, P. Kennedy and W. R. Hungerford. Mr. N. G. Stark represented the Oneida Pulley Co.

Cooper-Hewitt Co., Hoboken, N. J., exhibited both the long-tube Cooper-Hewitt lamp and the new quartz-tube lamp and the Cooper-Hewitt rectifier for operating direct current lamps. They also showed a special diffusing globe for use in connection with the high candle-power nitrogen-filled lamps. The company was represented by Messrs. F. M. Haviland and M. S. Buckman, Jr.

Edison Storage Battery Co., of Orange, N. J., exhibited various types of Edison nickel iron storage batteries for railway car lighting, baggage truck, signal and telegraph service. Large panels were exhibited on which all of the various processes in the manufacture of the positive and negative plates and containers were shown, from the crude material to the finished product. A compound sheet of 250 alternate layers of copper and nickel was exhibited to illustrate the method of procuring flaked nickel which forms the conducting element of the positive tubes. Messrs. H. G. Thompson, William G. Bee, W. F. Bauer, F. V. McGinness and Otto Hildebrand represented the company at the Convention.

Booth of the Edison Storage Battery Co.

Electric Controller & Mfg. Co,, of Cleveland, exhibited a lifting magnet in operation, automatic motor starter, automatic controllers and reversing planer drive, employing the Reliance reversing motor.

Electric Storage Battery Co., of Philadelphia, showed a complete operating exhibit of their new E. S. B. car lighting system. A motor with automatic control operated the car lighting generator at all the various speeds from zero to 90 miles per hour, and the generator current and voltage, lamp current and voltage, battery current and train speed were all indicated on meters mounted on a special panel beside the standard regulating panel of the system. It will be recalled that this equipment operates at constant potential and the manner in which the battery charging current tapers off was clearly demonstrated in this operating exhibit.

The new iron clad twin cell tank, specially designed for car lighting work, was also exhibited. This tank is 8 inches shorter than the standard lead tank and the weight has been reduced from 345 to 194 pounds for a 300 ampere hour cell. Tanks are lead lined and provided with metal cover.

Various types of storage batteries and individual plates for railway car lighting, signal and auto starting, lighting and traction batteries were shown. The company was represented by Messrs. Charles Blizard, E. L. Reynolds, F. L. Kellogg, J. L. Woodbridge, F. C. Beetem and H. E. Hunt.

Elwell-Parker Electric Co., exhibited their drop frame storage battery baggage truck, also trucks for their industrial work. The company was represented by Messrs. L. C. Brown and George W. Brown.

Gould Coupler Co. and Gould Storage Battery Co. occupied their usual booth at the end of the pier near the Convention hall. They exhibited their Gould Simplex system of electric car lighting with a motor generator set operating at all the various speed ranges, from zero to 90 miles per hour. The ball bearing mountings were shown and the covers were removed to show brush rig and bearings. A model of the pole changing device which could be turned with a hand lever was also shown. Their standard car lighting battery, one cell of which had part of the tray cut away so as to show the plate arrangement, was exhibited. They also exhibited malleable iron journal boxes, freight and passenger car couplers, friction draft gear, cast steel bolsters, frames and coupler yokes. The company was represented by Messrs. Geo. G. Milne, R. C. Hull, W. F. Richards, Dr. C. W. Gould, Clarence F. Rood, Col. John T. Dickinson, G. R. Berger and W. R. Shedd.

H. W. Johns-Manville Co., of New York City, exhibited their asbestos ebony board for switchboard panels, moulded insulation, fibre conduit, fuses, switchboards, line material, etc., as well as a complete display of asbestos materials, such as car insulators, pipe covers, etc. The company was represented by Messrs. F. J. Horne, J. H. Trent, R. A. Hamaker, H. G. Newman, Geo. Christenson, J. E. Meek, J. C. Younglove, G. A. Nicol and P. C. Jacobs.

Kerite Insulated Wire & Cable Co., of New York City, were represented at the Convention by the following gentlemen: Major Azel Ames, Warren Young, Geo. Graber and Percy Smith.

Mudge & Company, of Chicago, exhibited a new car ventilator of the box type, in designs for monitor and arch roof type cars. They also showed a large model of a novel spark arrester, which is manufactured by that company. The company was represented by Messrs. B. W. Mudge and G. W. Bender.

Okonite Company, of New York, had an attractive reception booth and exhibited numerous samples of wire for railway car wiring, power and signal work, and also sections of submarine cable. The company was represented by Messrs. J. D. Underhill, F. J. White and M. G. Hovey.

Pyle-National Electric Headlight Co., of Chicago, exhibited their types "S" and "E" headlight equipments. The type "E" equipment was described in the May issue of the *Railway Electrical Engineer,* and the type "S" is similar but of a smaller design, suitable for switch engines. Models and sectional views of the turbine were shown and headlights equipped with the new high power incandescent lamps, as well. The company was represented by Messrs. J. Will Johnson, R. C. Vilas, Wm. Miller, C. P. McGinnis and J. E. Kilker.

Railway Utility Co., of Chicago, exhibited both the standard utility round ventilator and the new honeycomb types of exhaust ventilators. Both of these have been giving excellent service during the past year, both in the way of maximum exhaustive capacity and complete prevention of reverse drafts carrying snow, rain or dust, whether the car is at rest or on the road. The company also showed their thermometer control for steam heat valves, hot water heating systems controlled by the same thermometer contact principle. The Utility steam hose described in our issue of June, 1912, was exhibited. The company was represented by Messrs. Lee P. Hynes, Wm. J. Pine and James Denton.

Safety Car Heating & Lighting Co., of New York, exhibited a complete assortment of car lighting fixtures, both electric and gas, for both passenger cars, baggage and postal cars. The various types are fairly well shown in the accompanying illustration, but we would call attention to the new semi-indirect bowl device for car lighting shown in the center of the picture, and also the new design of car fan shown just in front of it and slightly to the left. This fan has been specially designed for railway ventilating service and will be described in an early issue of the *Railway Electrical Engineer.* It is equipped with a set of slowly revolving vanes which deflect the air movement and give the same effect as an oscillating fan.

The "Safety" Booth; Note the New Type Car Fan in the Center Foreground.

Standard type "F" axle lighting equipment, driven by a motor at the various speeds of from zero to 90 miles per hour, was exhibited. A complete regulating panel with additional panel with meters for showing generator voltage and current, lamp voltage and current, battery current and train speed were installed. The company was represented by Messrs. R. M. Dixon, J. A. Dixon, A. C. Moore, J. S. Henry, R. C. Shaal, G. E. Hulse, W. I. Thomson, J. H. Rodger, Wm. St. John, M. F. Elliott, L. Schepmoes, S. I. Hopkins, W. L. Garland, Geo. H. Chadwell, R. H. Harvey, J. J. Molloy, C. W. Walton.

U. S. Light & Heating Co., of New York, had an operating exhibit with their type "C" regulating panel with an auxiliary switchboard and meters so that various currents and voltages throughout the system could be observed. Three types of generators were exhibited and one of the generators was partly dismantled, showing special ball bearing mounting. A new pasted plate car lighting battery was shown, which can be furnished in either 2 or 4 cells per tray. A new panel with Sangamo ampere hour meter for control of battery charging was also exhibited. The meter is used to control the circuit of the modifying switch. After the ampere hour meter registers full charge it makes a contact which energizes this switch and thereafter until the next stop, the equipment operates as a 36-volt constant potential system, so that the battery simply floats on the line. The U. S. L. automobile starter and signal batteries were also exhibited. The company was represented by Messrs. W. L. Bliss, J. G. Pomeroy, C. C. Bradford, H. A. Matthews and G. H. Burrell.

U. S. L. Booth.

Westinghouse Electric & Mfg. Co. did not exhibit any apparatus in the booth this year, confining its space to a reception room which was well lighted by the new Westinghouse nitrogen-filled incandescent lamps, and cooled by a number of Westinghouse fans. The railway coach fan was also shown in operation.

Reception Booth of the Westinghouse Companies.

At the end of the pier the Westinghouse Electric Company had installed and in operation a complete arc welding outfit which was of great interest to the visitors of the Convention on account of the recent rapid increase in the use of this class of apparatus. The outfit included one 300-ampere motor-generator set consisting of one 75-volt, 300-ampere, 1,170 r. p. m. direct current generator direct connected to and mounted on a common base with one 30 h. p., 200-volt, 3-phase, 60-cycle, alternating current motor; carbon holder; hoods for protecting the operator; screens for use when making short welds; carbon electrodes and switchboard to control the set. A number of extra screens were provided for the visitors so they could observe the actual operation of the arc when performing the different operations made by it.

The following representatives were in attendance: W. H. Patterson, East Pittsburgh; H. C. Mode, Pittsburgh; L. W. Popp, Chicago; R. F. Moon, Philadelphia; J. L. Hays, Baltimore; J. C. McQuiston and H. W. Beaumont, East Pittsburgh.

The Westinghouse Lamp Company had on exhibit a number of lamps, above mentioned, used in lighting the booth, and was represented by W. H. Rolinson, commercial engineer, and A. R. Ross, commercial engineering department, both of New York City, and Chas. A. Dostal, district manager at Philadelphia.

Magnetic Properties of Electrolytic Iron Melted in Vacuo.

"Magnetic and Other Properties of Electroyltic Iron Melted in Vacuo," by Trygve D. Yensen, has just been issued as Bulletin No. 72 of the Engineering Experiment Station of the University of Illinois.

The efficiency of electrical machinery depends largely upon the magnetic quality of the iron from which it is made. On this account a large amount of work has been done during the last decade by numerous investigators to decrease the hysteresis and eddy current losses of iron and to increase its permeability. Bulletin No. 72 records the results obtained by melting electrilytically refined iron in a vacuum furnace. It shows that by this process it is possible to obtain iron with a carbon content of 0.1 per cent or less without oxidation of the iron. The maximum permeability of this iron at ordinary temperatures is shown to be 19,000, occurring at a flux density of 9,500 gausses. The hysteresis loss is from one-half to one-third of that for the best transformer steel used at the present time. The bulletin is illustrated by numerous photomicrographs showing the crystaline structure of the pure iron as well as the structure of iron produced under less favorable conditions.

Copies of Bulletin No. 72 may be obtained gratis upon application to C. R. Richards, Acting Director of the Engineering Experiment Station, University of Illinois, Urbana, Illinois.

Tests of Tractive Resistance.

"The Tractive Resistance of a 28-Ton Electric Car," by Harold H. Dunn, has just been issued as Bulletin No. 74 of the Engineering Experiment Station of the University of Illinois.

This bulletin records the results of tests made to determine the tractive resistance of a 28-ton electric car when running on straight track in still air. The tests were planned so as to eliminate wind desistance. The results are finally expressed in the form of a curve whose co-ordinates are car resistance and speed, which shows that the resistance varied between 5.25 pounds per ton at 5 miles per hour, and 26.12 pounds per ton at 45 miles per hour. The bulletin contains also a description of the car.

Copies of Bulletin No. 74 may be obtained gratis upon application to C. R. Richards, Acting Director of the Engineering Experiment Station, University of Illinois, Urbana, Illinois.

Track Scale and Yard Lighting

H. Kirschberg and A. C. Cotton

The track scale and classification yards of a division might be compared to a nerve center of the human body—trouble causing a tieup or delay, or even poor efficiency at this point will affect the entire system.

The paper shows the need of a correct system of illumination since a large part of track scale work is done at night. A layout for proper illumination of track scale is given and also many suggestions as to system of lighting classification yards. System to be selected, however, depends upon amount of money available for the purpose, the ideal system being a row of small units between each pair of tracks.

Relative advantages of the various types of lighting units are given.

Coincident with the development of illuminating engineering, there arose in railroad circles a conception of its applicability to the manifold problems peculiar to transportation, as a means of not only improving and increasing service and results, but in a multitude of cases, of finally solving a number of problems which hitherto had been satisfied with but only a limited degree of success. Not the least among the conditions to be met with in the field of railroad illuminating engineering are some with which the public does not even come in contact, but which nevertheless are really of vital importance either to their safety in travel or to the railroad as a source of revenue.

It is a well known fact that the main source of revenue to a railroad is its freight haulage, the carrying of passengers in a number of instances in this country being in reality maintained at a loss to be offset by other income. Anything, therefore, which will to any degree assist in the movement or improvement of freight traffic will show a large earning capacity of the road equipment and to that extent improve both the financial condition of the road and its ability to serve the public in every way required of such corporations. This paper has, therefore, been written with a view to showing how, in just one location, an improvement in the lighting condition may produce the beneficial results mentioned before.

As in the body, a railroad may be said to have a number of larger nerve centers or ganglia from which radiate the smaller nerve fibers to exercise their functions in those portions of the body segregated from the main trunk. These centers as applied to freight traffic are the engine house, the receiving and classification yards and the track scale and their auxiliaries; failure of operation in anyone of these might produce a complete tie-up similar in every respect in our simile to paralysis, and which might just as surely creep until the larger nerve centers or terminals are affected, and the entire system becomes paralyzed.

Of the many special problems of illumination presented on a railroad, none perhaps is of more importance, from a railroad viewpoint, or capable of more solutions than that of track scale lighting. A modern track scale, as shown in Fig. 1, is a scale from 37 ft. to 83 ft. in length, and of 300,000 lbs. capacity, built on a concrete foundation, set in the line of track and connected by means of levers to the scale beam in the adjoining scale house. It is used to weigh all freight passing over the road, a large percentage of which is weighed at night, thus necessitating a good lighting system in and around the scale house.

As the car passes over the scale at a speed at about 2.5 miles an hour, the weighing is done. In addition to the weighing, the number and light weight of the car is read from either the ends or sides of the car, and a record of them made on the manifests in the possession of the weighmaster. The entire operation takes from eight to twelve seconds. It is also necessary to see under the car to a certain extent, in order to determine whether the car is entirely on or partly off the scale. Each car is in charge of a rider, who keeps his position on the car until it has passed over the scale.

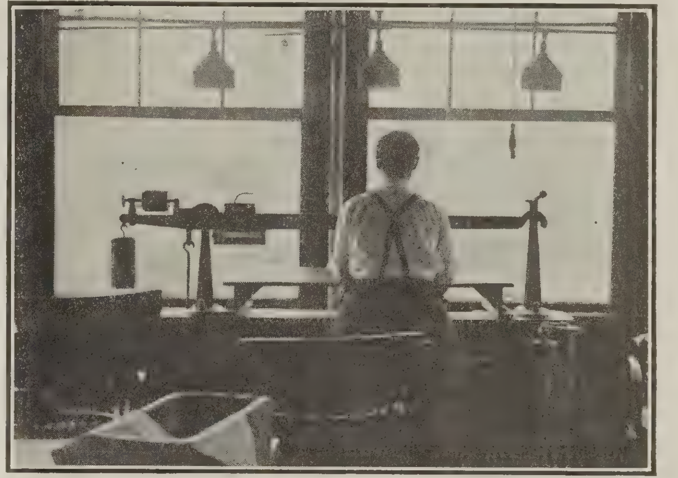


Fig. 1. Showing the Interior of Scale House.

The conditions to be met in the lighting of the location are, therefore, as follows:

1. Sufficient illumination in the scale house, with special attention to the scale beam in the bay window, to permit rapid and accurate weighing. At the same time the lamps should be so placed and shielded that none is in the field of vision either from the inside or outside of the scale house, and that no reflection of the lamps is seen in the windows, thus making it very difficult to see numbers on the cars outside. If interior lamps are visible from the outside, the glare may be sufficient to prevent good vision around the hump and clearance grades, so resulting in possible accident to riders and car cutters.

2. Sufficient illumination outside the scale house to permit those inside and those outside to perform the following duties:

   Safe cutting of cars at the hump.
   Location of car at every point in its movement.
   Clear sight of movement of every wheel on to the scale.
   Reading of light weights and numbers on ends of approaching cars.
   Reading of these weights and numbers on side of car on scale. For this work a clearance of 2 ft. 11.5 in. (0.90 m.) is all that is allowed.
   Reading of the light weights and numbers on the receding end of car, if not procured during either of the two aforementioned intervals.
   Movement of wheels off the scale.
   Clear sight of movement of car down the clearance grade in order to safely pass the next car over the scale.

---

*A paper presented before the Pittsburgh Section of the Illuminating Engineering Society. February 13, 1914.

Location of position of car on the clearance grade in order not to bump cars too hard when making up drafts of cars to go down the classification yard.

It is evident that the weighmaster must look from a well lighted room into an illuminated open space with a dark background in order to work; also that the riders are continually moving from a well lighted zone into one with a very low intensity of illumination. Glare in such cases is productive of not only danger to individuals, but also possible damage to equipment and loss of time and money. It would assuredly not be correct to use the general yard lighting system for lighting the exterior, for the reason that light is needed at the scale sometime before the yard lighting is necessary.

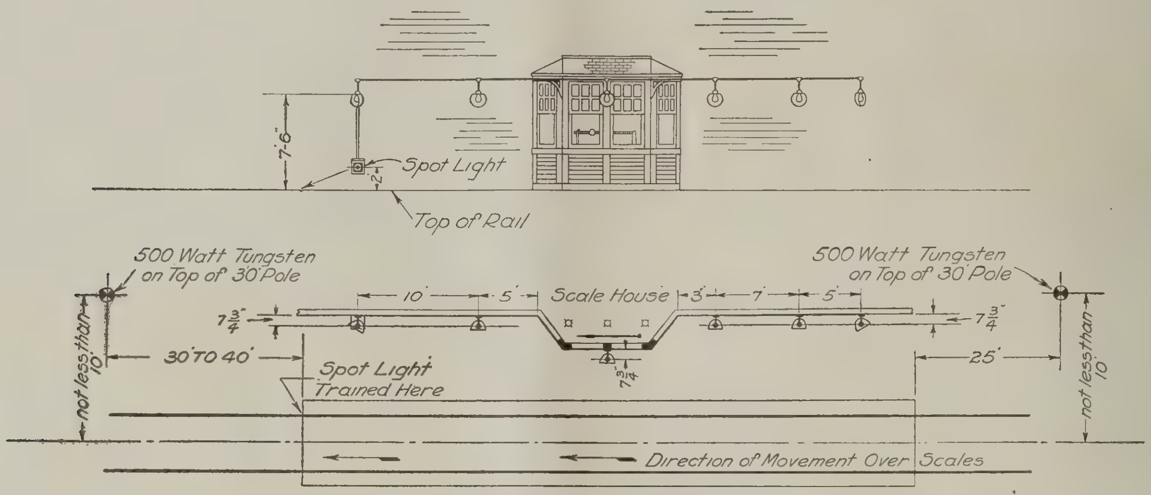


Fig. 2. Layout for Proper Lighting in Front of Scale House.

All scale lamps should, therefore, be on a seperate control. With the low height of roof, the small roof overhang, and the narrow space between the side of the car and the scale house window, the problem of placing units of large enough capacity and sufficiently low intrinsic brilliancy to do the work is not a very simple proposition. The outside lamps should by no means be visible to the weighmaster.

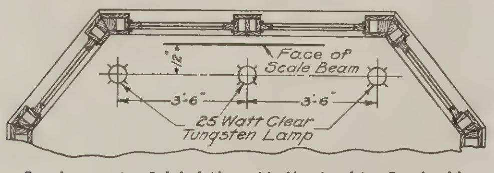


Fig. 3. Layout of Lighting Units Inside Scale House.

In locations where an office building is in use in addition to the scale house, the entire front of the building is available for the placing of lamps, thus offering another solution to the problem as shown in Fig. 7.

There are, no doubt, a number of methods of obtaining the desired results, but inasmuch as an engineer is one who is supposed to do for one dollar what anyone else can do for two dollars, it is evident that the cheapest and at the same time equally reliable and successful solution is the only one deserving of the appellation of illuminating engineering.

The location of the neighboring lighting units, such as may be used for yard or office lighting, will, of course, affect the efficiency of the scale lighting installation. Each case, therefore, contains some feature not found in other cases, for which it is evident that a study of local conditions for each scale is necessary. Track scales often being located at points somewhat distant from power plants, the electrical conditions usually furnish an alternating current, in which case the choice of efficient lighting units and desired distribution of light is narrowed still further than under other conditions.

Classification Yard Lighting.

A classification yard is used for the purpose of collecting freight cars into trains for particular routes and destinations. After a collection freight train has covered its allotted division taking all cars which have been loaded for shipment, it enters a receiving yard where each car is inspected for defective running gear and where it is held until opportunity is afforded for it to pass over the scale, at which point each car is weighed and recorded as explained before. The switching, done below the scale clearance grade, is controlled from a tower usually situated near the scale house. Various layouts of tracks, pick-up tracks, etc., are in use, but a discussion of these is not necessary in this article. The trackage layout, however, should provide space for poles on which to mount lamps, and inasmuch as this lay-out is drawn up by the maintenance of way department, it is to be ex-

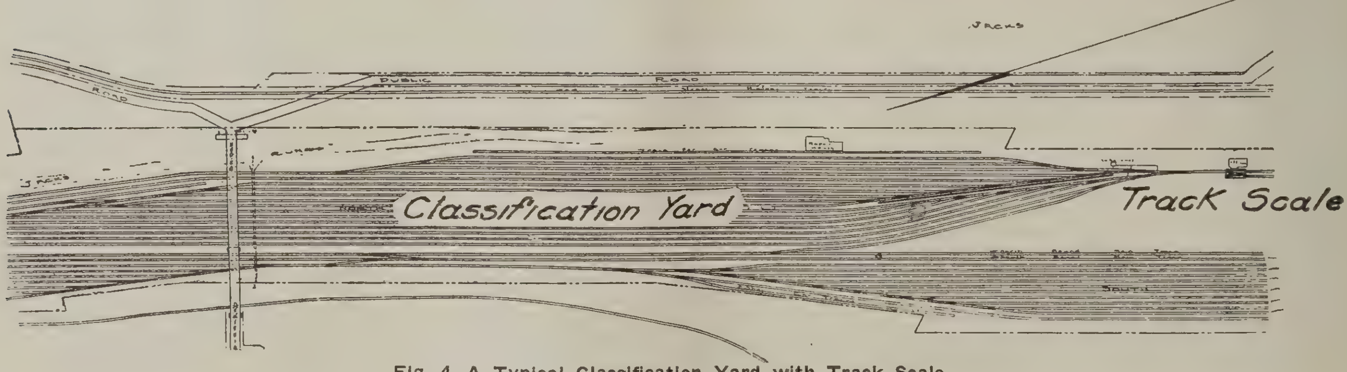


Fig. 4. A Typical Classification Yard with Track Scale

pected and is also true that the space allotted to the lighting is not only often insufficient, but also poorly located. The usual lighting scheme employs a line of arcs down the center of the yard and a line on each side.

Other methods have also been used, with as poor results, but being improvements over still poorer original methods they have been voted successes. A discussion of some of these methods will follow later in this article. For a moment, however, and in line with a previous thought expressed herein, the authors desire to present the probable consequence of a failure of light in a classification yard with the object of showing that the initial cost to obtain a correct layout will be but a small part of the loss produced by a failure, and that such an initial cost is justifiable, no matter how high it may be in comparison with the past practice.

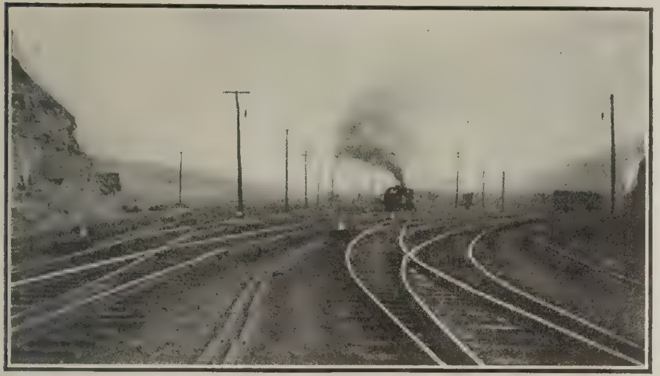


Fig. 5. Illustrating the Bad Practice of Laying Out a Yard and Locating Lighting Units Afterward.

As stated by the writer before, the major portion of a railroad's revenue depends on its freight haulage capacity. This capacity is as dependent upon scale and yard capacity as it is upon motive power equipment, and a congestion in either the receiving or classification yards or a reduction in car movement over scales will reduce earning power as well as will a disablement of locomotives or a lack of cars. Naturally, loss of revenue from any of these causes carries with it a cumulative losing effect due to loss of prestige and goodwill of the shipping public. Bearing in mind the fact that work of the nature explained herein continues both day and night, it must be evident that a disablement of a classification yard imposes a momentary loss of no small magnitude to a railroad.

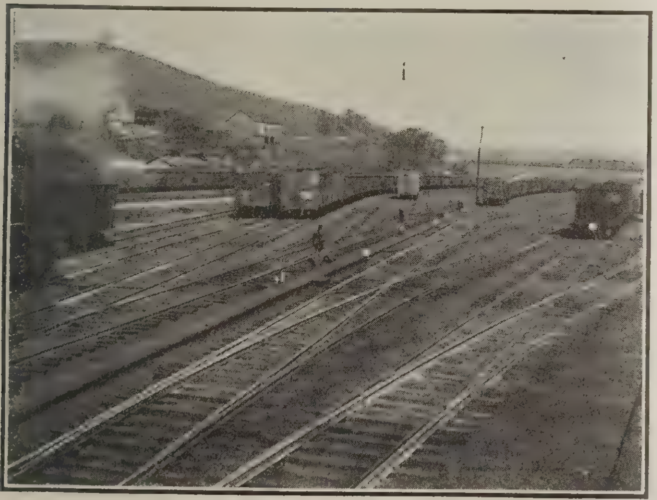


Fig. 6. This Is Better than Fig. 5, from an Illumination Point of View but Probably Much More Difficult to Maintain.

Many engineers in designing this class of lighting have considered a classification yard as an open space and have lighted it accordingly. An error of this sort will show, upon reflection, an incompetent consideration of the conditions to be met. Quite contrary to this idea, the problem of classification yard lighting may be stated to be more involved than any problem of street or park lighting. A classification yard consists of a series of streets 3 to 4 ft. wide, with buildings about 14 ft. high on both sides. The ideal system would, therefore, provide light on and between every pair of tracks. How close the ideal may be approached depends upon the aloted appropriation and the desires of the corporation and the designing engineer.

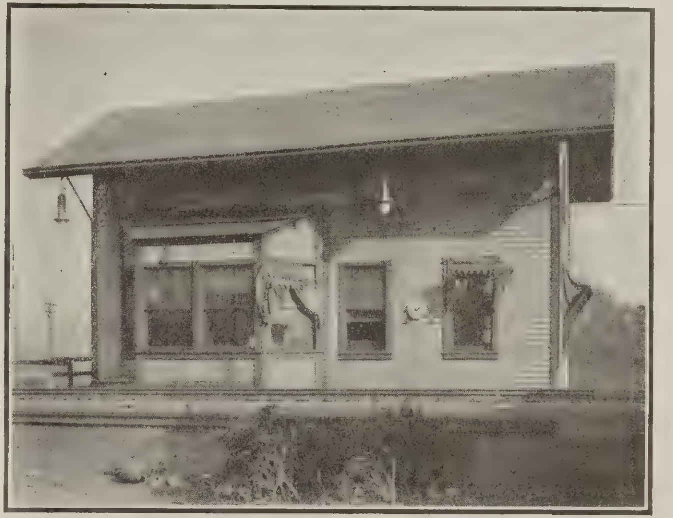
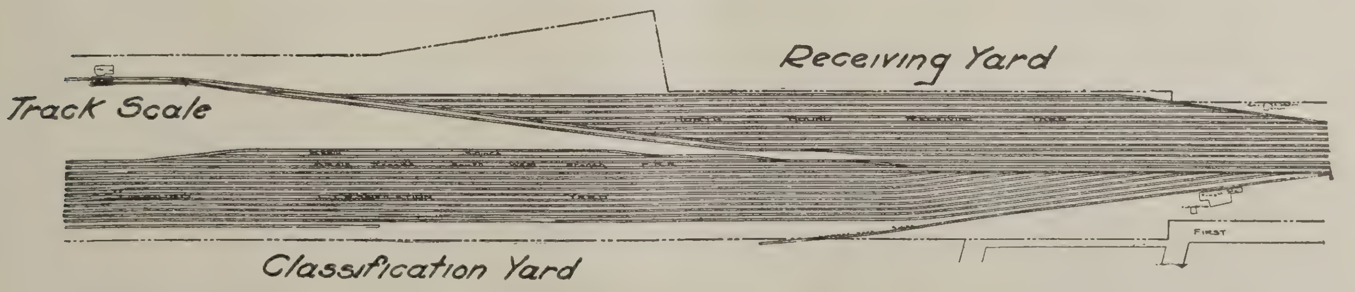


Fig. 7. Where An Office Building Is in Connection with Scale House, This Offers Excellent Means of Supporting Light Units Properly.

The conditions to be satisfied may be briefly stated as follows:

1. Illumination of the grade leading from the scale to the yard.
2. Illumination of the switches at the head of the yard to facilitate control of car movement from the switch tower.
3. Illumination of every track, irrespective of position of adjacent car.
4. Illumination of every car in the yard.
5. Absence of glare from every position in the yard.

The foregoing requirements must be accomplished



without the retention of too much space from trackage, this space usually being allotted in advance, without regard to its adaptability for the purpose intended. The further consideration of type of illuminant and system to be employed will, therefore, be more or less dependent on other factors.

Many different methods have been employed, among which may be mentioned the following, with some of their advantages and disadvantages as viewed from an up-to-date standpoint, and in the light of the latest developments in lighting units.

Series A. C. Enclosed Carbon Arc Lamps.

Advantages.

- Simplicity.
    - Generation of current.
    - Distribution of current.
- Easy control.
    - All advantages of enclosed over open arc.
    - Cheapness.

Disadvantages.

- Poor power factor.
- Low efficiency.
- Poor distribution of light.
- Necessity for reflector.

Series D. C. Enclosed Carbon Arc Lamps.

Advantages.

- Same as series A. C. enclosed carbon arc with better distribution of light.

Disadvantages.

- Low efficiency and high maintenance cost when compared to latest series arc systems.
- Necessity for converting apparatus in an A. C. plant or for a Brush arc machine.

Flaming Arc Lamps.

Advantages.

- Series or multiple.
- Long trim.
- High efficiency.
- Low maintenance cost based on flux of light produced.
- Good distribution.

Disadvantages.

- Tendency to flicker.
- Necessity for extraordinary attention.

Arc Projector Lamps.

Advantages.

- Simple control.

Disadvantages.

- Light all thrown in one direction, thus producing objectionable glare.
- Limited area illuminated at any one time.
- Traveling of car in its own shadow.
- Blinding effect on return trip of rider resulting in danger.
- Lower efficiency of lamp compared to luminous and flaming arc lamps.
- Illumination of yard dependent upon a single source of light.
- Total interception of light by string of cars on tracks adjacent to running track.
- Necessity for constant attendance.
- Necessity for special electrical apparatus to secure direct current, low voltage supply if transmission line is alternating current.
- Interference, due to glare, in adjoining yards or on main line tracks adjoining.
- Necessity for additional auxiliary lamps throughout the yard.
- Inability to distinguish signals in the glare, especially green signals.
- Excessive cost of maintenance.
- Short life of trim—three and one-half hours.

Luminous Arc Lamps.

Advantages.

- All advantages of series systems in general.
- Good distribution of light.
- High efficiency.
- Long trim.
- Reliability.
- Low maintenance cost based on flux of light produced.

Disadvantages.

- Necessity for converting apparatus in an A. C. plant or for a Brush arc machine.

Series Tungsten Lamps.

Advantages.

- All advantages of series systems.
- Almost ideal distribution, if installed correctly and small units used.
- Either direct or alternating current.
- Good efficiency.

Disadvantages.

- High initial cost of installation, if small units are used (posts or catenary construction).
- Necessity for reflectors to obtain desired distribution and overcome glare due to the low height of lamps, if small units are used.

Quartz Lamp.

Advantages.

- High efficiency.
- Good distribution for high mounting.
- Good color value for outdoor illumination.
- Large flux of light, which due to light distribution of the unit can be used to good advantage by high mounting of the lamp and large spacing.
- Steadiness.

Disadvantages.

- Requires direct current.
- Is multiple unit only, necessitating large copper and large C_2R losses.
- Large variation in candle-power with variation in temperature controlled only by readjusting resistances.
- Present lack of data on reliability of operation and life of burners.

In Europe flaming arcs are at present being used to a great extent for railroad yard lighting. Labor and material costs here, however, have held up similar action in this country for the present. The question of how large or how small a unit to use depends on how close an approach to the ideal of bright moon light is desired. Other questions of maintenance are secondary, especially when the results of a failure are considered. The best that can be hoped for at present is the awakening and realization of the railroads to the value of good yard lighting. The best method will then be determined by intelligent effort and trial, if not by natural process of improvement and elimination.

The authors desire in conclusion to express their appreciation for the courtesies shown by the Pennsylvania Railroad in furnishing valuable data used in the preparation of this paper.

Storage Batteries for Headlight Service.

The Southern Pacific Railway Company has given the Electric Storage Battery Company, of Philadelphia, an additional order for 650 sets of "Ironclad-Exide" batteries for locomotive headlight service.

With the previous order received several months ago, this makes a total of 946 sets—2,838 cells—of Type 13-MV "Ironclad-Exide," which will be used in this class of service by the Southern Pacific Co.

The ruggedness of this type of battery, its long life, and the fact that it can be operated for long periods without cleaning, make this battery peculiarly adaptable to the severe service requirements in this class of railway service.

The Bristol Belt Fastener.

A new belt fastener has recently been put on the market by the Bristol Company, of Waterbury, Conn. This consists of a heavy steel plate, which is placed over the belt joint and fastened to the belt with split rivets which clinch securely on the under side of the belt. The plates are curved to fit the curve of the pulley and the edges are turned up to prevent cracking. Copy of the bulletin will be forwarded to any of our readers upon request to the Bristol Company.

The Lead Storage Battery

In Railway Car Lighting and Signal Work. H. M. Beck

From an operating standpoint the lead storage battery is one of the very simplest pieces of electrical apparatus, and my first advice would be to always consider it as such. When problems arise look for a simple explanation. Do not think it is necessary to find a complicated answer. There is entirely too great a tendency for those who are not chemists to attempt to go into the chemical theory of the storage battery. They find it involved and come to the conclusion that there is something mysterious about it. This is all wrong. Think of a battery as a simple device and give it straightforward simple attention.

Theory of the Storage Battery.

From a mechanical standpoint a storage battery could hardly be simpler. It consists essentially of two sheets of lead insulated from each other, and submerged in a solution of sulphuric acid and water. When these plates are charged one, the positive, is oxidized and turns a brown color. When they are discharged the positive loses its oxygen and turns a lighter color, and at the same time acid from the solution combines with both plates and thus weakens the solution iself.

The electrical capacity of the cell depends upon the surface exposed to the solution, and in order to increase this capacity the surface of the plates is covered with a finely divided or sponge lead, and the plates themselves are often corrugated or ribbed. This finely divided lead is mechanically weak, and has to be supported by the frame of the plate itself, known as the grid, but nevertheless it constitutes the working or active material, and in principle the plates simply still remain two lead sheets having very finely divided surfaces, insulated from each other and submerged in a solution of sulphuric acid and water.

There are just two points in this theory which should be kept clear:—First, that the positive is oxidized during charge and loses oxygen during discharge; and second, that the acid from the solution which has combined with the plates during discharge is driven back into the solution during charge. These actions result in the voltage and specific gravity increasing during charge and falling during discharge; and these facts are very vital in the operation of storage batteries, since through them we have the means of following the charge and discharge of the cells and operating efficiently. Remember, therefore, that during charge the positive is oxidized, and the acid is driven out of both plates, causing the voltage and specific gravity to rise; and, that during discharge the positive loses oxygen, and both plates absorb acid, causing the voltage and specific gravity to fall.

We can amplify this a little further and say that the voltage and gravity will continue to rise or increase as long as the positive is being oxidized, or any acid is being driven out of combination with the plates, which actions correspond to the storing of the charge. When, however, all of the active material of the positive plate has been completely oxidized, and all of the acid driven out of both plates, the voltage and gravity reach a maximum and come to a standstill, and this point corresponds to the complete state of charge. Unfortunately, we cannot reason quite so logically with reference to the discharge, as while the discharge limits have been fixed very definitely, they are deduced simply from experience, it having been found that below certain voltages or gravity drops there is very little capacity available, and that, further, any extra capacity obtained below the limits, is obtained at the expense of efficiency.

Operating Characteristics.

So much for theory. Let us now consider the characteristics of the storage battery from an operating standpoint, and, as will be noted, our methods are based almost entirely on experience rather than on theory; and this in itself bears further evidence to the fact that the ordinary operator need not bother himself with any great amount of theory.

In connection with charging two points come up. What rate shall be used, and how shall we determine when the cells are fully charged?

The rate question is easily settled as far as the safety of the battery goes. Use any rate you wish, provided you do not heat the cells, and the rate is not above normal after the cells reach the gassing point. High temperatures are injurious to the plates, and we usually fix the high temperature limit at 110° F. Excessive gassing acts like a brush on the positive plate and mechanically washes out the active material, and this naturally reduces the capacity. Otherwise, as far as the cells are concerned, it is perfectly safe to charge at any rate at any time, and since the cells do not begin to gas and show only very slight tendency to heat until near the end of charge, it is thus often permissible, during the early part of a charge to charge at very high rates up to many times normal. In fact it will generally be found that at such times the wiring or capacity of the power plant, rather than the storage batteries, limits the rates which can be used, and it is evident that, where desired, very considerable capacities can be put back into a completely discharged storage battery in a very short time. This will be taken up later.

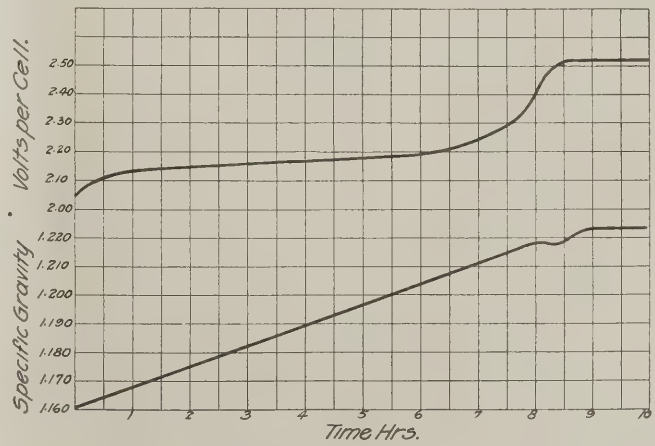


Fig. 1. Curves of Voltage and Gravity Charging at Constant Current.

The method used for determining the limit of the charge depends upon how the charge is being carried out, and in most cases several methods are available.

A talk given before the May meeting of the R. R. Electrician's Club, Chicago.

Constant Current Charging.

Fig. 1 shows the most common method of charging; that is, where a constant or fixed charging rate is used —usually the normal. As will be noted, the voltage rises rather suddenly at the start, then gradually increases during the main part of the charge, jumps up again suddenly towards the end, then gradually flattens out until it shows no further increase and becomes a straight line. As already explained, this point represents the fully charged condition, and we have, therefore, the first means of determining when the cells are fully charged; that is, when the voltage reaches a maximum and shows no further increase.

As will be noted, the gravity curve is a straight line bending over and showing no further rise when the cells are fully charged. This, then, is the second method of determining the completion of the charge; and in connection with both of these methods, the voltage and gravity, it should be kept clear that the indication of the completion of the charge is not that the voltage or gravity have reached any particular values, but rather that they have reached a maximum beyond which they would show no further increase no matter how long the charge was continued.

As long as the cells are storing the electrical energy put into them, they show very little action, but when the plates are nearly fully charged, the energy which can no longer be absorbed shows itself in the form of gassing or bubbling at the surface of the electrolyte; until finally when the plates are no longer absorbing any of the energy, the gassing is very marked.

This free gassing begins at about the point at which the voltage curve takes its second jump, and gassing can be used as a rough guide for determining when the cells are chared, but at its best is only a rough indication.

Another method coming into quite general use, is the ampere hour meter, an instrument for measuring the ampere hours put into a battery or taken out of it. The method of using this instrument depends upon the observed efficiency of a storage battery, the method of procedure being to put into the cells on charge an excess in ampere hours sufficient to make up for the losses in the cells. Thus, if we observe the ampere hours on any discharge, and charge in some 10% or 15% more ampere hours than were taken out, experience shows that the battery will probably be charged about right. Where this method is used, however, it should be checked at intervals by the voltage or gravity. Many ampere hour meters are designed so that they automatically take care of the efficiency of the cells; that is, run slower on charge by a given per cent than on discharge. With such instruments all that is necessary is to charge until the indicating hand of the ampere hour meter is brought back to zero, and this will automatically correspond to charging in a given per cent above the amount of the discharge.

Constant Potential Charging.

Fig. 2 shows another method of charging which has not as yet come into such general use in railway service, but which is likely to become quite common since with slight modification it is that which has been recommended by the committee of the Association of Railway Electrical Engineers. According to this system the battery is charged at a constant potential rather than a constant current. As will be noted, the charge starts at a very high rate, and as the voltage of the cell rises the current tapers off until it reaches a comparatively low value. This characteristic has the advantage of a high rate charge when the cell is in condition to absorb the charge readily, the current being automatically reduced so that when the cell begins to gas the gassing will not be violent. On the other hand, it has the objection that without modification the initial charging rates may be higher than the car wiring will stand, and in any case throw very heavy loads on the power plant. In order to overcome these objections, the system has been modified by placing a resistance in series with the battery, with the result that the initial current is very much flattened out, the current starting at a lower value and tapering less abruptly; in other words, approaches more nearly the constant current charge. In fact by using sufficient series resistance the charging current can be made nearly constant. This modified system, therefore, overcomes some of the objections of the straight, constant potential method at the expense of efficiency, due to the loss in the series resistance. For plain, constant, potential charging a voltage of 2.30 volts per cell is about as high as should be used, whereas with a series or ballast resistance of .07 ohms per cell, one of the large roads is using the constant potential of 2.94 volts per cell.

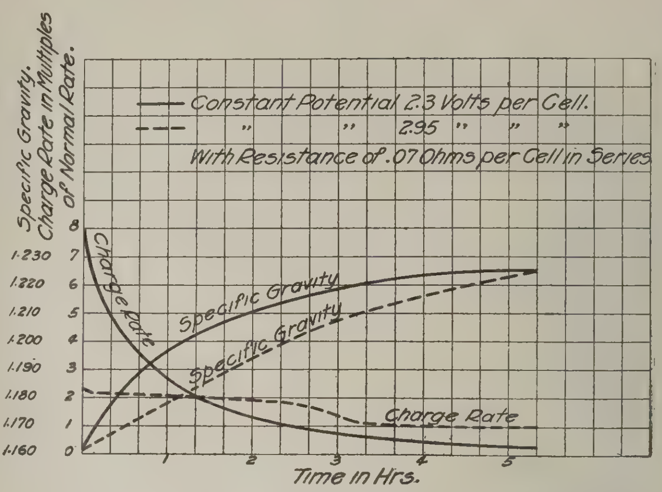


Fig. 2. Constant Potential Charging Suitable for Yard Systems.

As will be noted, the gravity curve in this case is not a straight line, but gradually flattens out as the current rate decreases, and still eventually becomes a horizontal line when the charge is completed.

Due to the varying charging rate, the voltage method of determining the completion of charge is not applicable to the constant potential system. We can, however, use the gravity, ampere hour meter or gassing, as already explained.

Fig. 3 shows a low pressure constant potential charging system, which would hardly be practical for

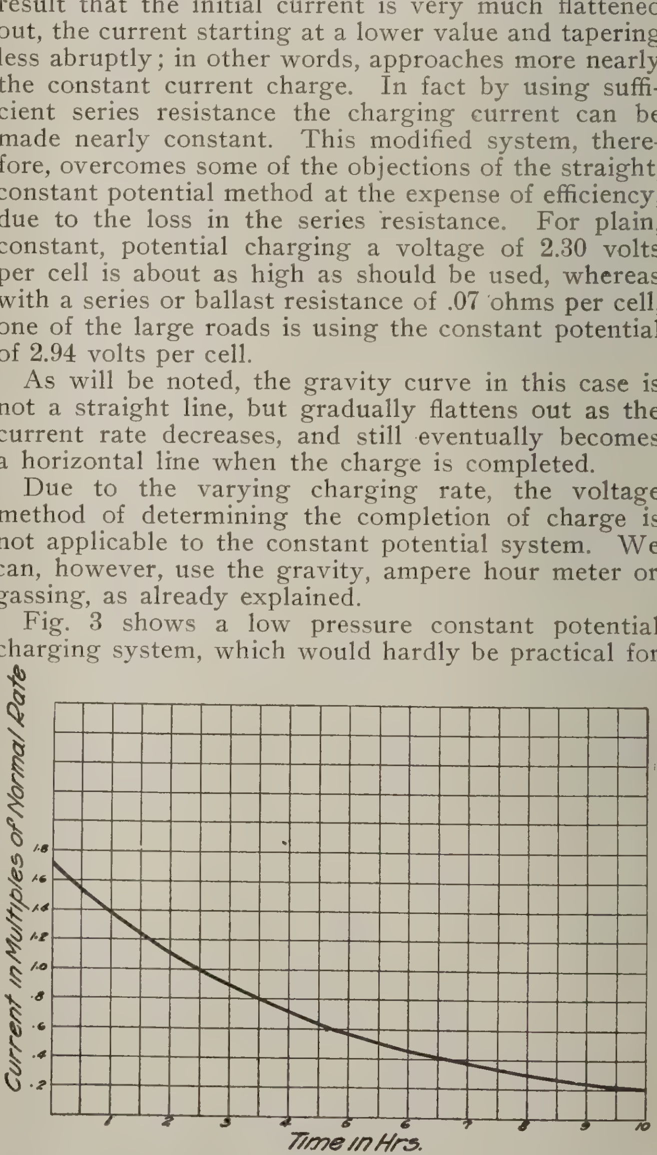


Fig. 3. Constant Potential Charging at Voltage of 2.2 Volts per Cell.

yard charging, but which is being advocated for use in connection with axle systems. With this system the charging voltage is placed so low—2.2 volts per cell—that when the cells become completely charged their own voltage automatically cuts the charging current down to practically zero. For yard charging the time required with this system for complete charge would probably be too long, but on the other hand for use in connection with axle equipments it has the advantage of using the characteristic rise in voltage of the cell during charge to cut down the charging rate as the charge progresses, until finally the charge is reduced to practically zero, and the charge carried out automatically without any attention being required. No method for determining when the charge is complete is necessary with this system, as long as the battery takes current it needs it, and it will no longer take current when charged due to its own counter-voltage.

As already stated, by taking advantage of the fact that during the early part of the charge of the lead storage battery, due to its very low internal resistance, can safely absorb the charge very rapidly, it is possible to put into a battery a very large percentage of its capacity in a very short time. This fact should be of special use in car-lighting work where a battery needs charge and has to be sent out on short notice.

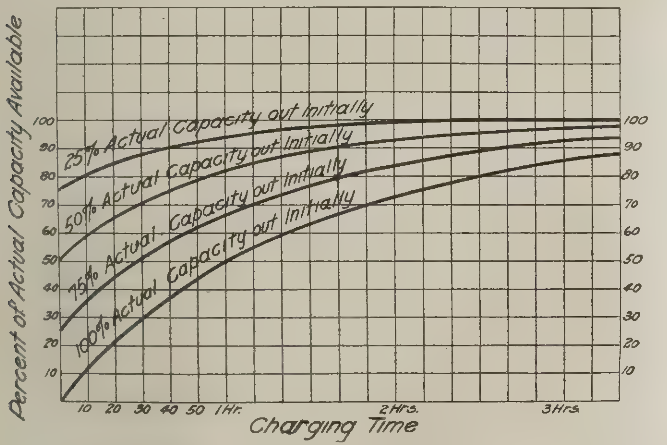


Fig. 4. Percentage of Capacity Which Can Be Put Back with Boosting Charges in Certain Lengths of Time.

Fig. 4 shows the percentage of the normal capacity which can be put back into a battery in various lengths of boosting charges of this kind. The method employed is one already referred to in connection with the constant potential charging, and consists in applying a constant potential across the battery up to 2.3 volts per cell, and allowing the battery to take all the current it will, or that the wiring will stand. A voltage of 2.3 volts per cell is safe, as far as the gassing or heating of the cells is concerned under any ordinary conditions, but this is about the highest voltage that it is wise to employ under practical conditions. Fig. 4 is based on a boosting voltage of 2.3 volts per cell, and as will be noted, with this pressure the cells will absorb about one-half of their normal rate capacity in one hour's charge. It should be emphasized that while the charging rates may seem high, due to the fact that they are used when the cell is rather completely discharged, they are not injurious.

Specific Gravity Readings.

Fig. 5 shows how the voltage and specific gravity behave during a normal rate discharge. The discharges are not usually under control in railroad work, so that these are probably only of interest in conneciton with tests.

Either the voltage or gravity drop is used for indicating the discharge limit, and as already explained, these limits are fixed arbitrarily. The voltage limit is usually placed at 1.75 to 1.80 volts per cell, and as will be noted, beyond this point the voltage drops so rapidly that only slight additional capacity would be obtained if the discharge were continued. Further, this discharge would be obtained at the expense of the efficiency and life of the plates, so that it is advisable to stop the discharge at this point.

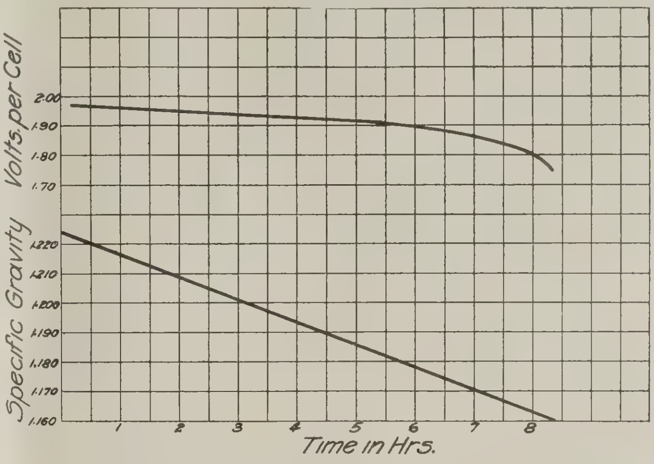


Fig. 5. Showing Voltage and Gravity of Cell on Discharge.

Unfortunately the voltage of a cell at any time is directly dependent upon the current flowing either during charge or discharge, and, therefore, except where there is a known constant current flowing, the voltage is not of much use in indicating where the cell stands. On the other hand, the specific gravity reading is practically independent of the current rate and indicates directly where the cell stands even on open circuit. Consequently, it is of much greater use than the voltage for indicating the amount of discharge.

The specific gravity drops directly in proportion to the ampere hours discharged, so that if we determine the drop corresponding to, say, the normal rate capacity to the limiting voltage, by taking a reading at any time, determining the drop, and comparing this with the drop corresponding to the full capacity, we know at once how far the battery is discharged. The specific gravity drop varies in different sizes of cells, depending upon the quantity of electrolyte in the jar or tank. For car-lighting cells it runs in the neighborhood of 70 points. Thus, if a reading at any given time shows a drop of 35 points, this indicates that the cells have been discharged to one-half of their capacity.

A second method of checking the discharge is through the use of the ampere hour meter. In other words, knowing the capacity of the cell, the ampere hour meter shows how much has been taken out at any time.

Effect of Temperature on Batteries.

Temperature affects the action of a storage battery in several ways, and its influence should not be overlooked, or it is likely to cause some confusion.

The effect of temperature on the capacity of the lead storage battery is almost negligible. There is a slight increase as the temperature rises, and a slight loss as the temperature falls, but this amounts to only about ½% per degree at normal rates of discharge, is still less at lower rates or where the discharges are interrupted, and so is practically negligible in railroad work.

As the temperature increases the voltage of the cells on discharge increases slightly, and decreases on charge, but the amount is not sufficient to affect the discharge voltage limit, and since we do not depend upon fixed voltages for cutting off charges it does not affect our operating methods as far as the charge is concerned.

Under the old method of limiting the charges, employed some years ago, where the cells were considered charged when they reached some set voltage—2.50 volts per cell—temperature had an important bearing; as, for example, the same cell in the same condition of charge might read anywhere from less than 2.40 to over 3 volts, depending upon the temperature, and this fact shows very clearly one of the reasons why this method of charging was abandoned. Where, however, we charge until the voltage ceases rising, no matter what the actual voltage reached is, changes in temperature are automatically compensated for and do not have to be taken into consideration.

Specific gravity readings vary directly with the temperature, decreasing as the temperature rises, or increasing as it falls about one point for every three degrees variation. This change is entirely independent of the action of the cell and would take place whether there were any plates in the electrolyte or not, and, as in the case of the voltage, the regular methods of operation automatically take care of this change and it does not have to be considered in car-lighting service.

Electrolyte.

The strength of the electrolyte is the one element of a storage battery which is in the hands of the user. Other parts may require renewal, but standard parts are used for replacement so that the design is as originally intended. The strength of the electrolyte, however, that is, the relative amount of acid and water, is in the hands of the user, and he is in a position to make it anything he wishes. While conditions in regard to the electrolyte are improving, they are still far from what we would like, and the situation is a very good illustration of the proposition I started out with, i. e., that whereas a battery is a very simple device and should be handled in a simple manner, there is a decided tendency to look upon it as something mysterious, requiring mysterious treatment. In this direction it is often thought, for some mysterious reason, that unless the specific gravity is kept exactly at the right point, a cell will not work properly. There is a further idea that acid is actually used up as the cells operate and has to be replaced, this idea being possibly derived from the fact that the solution of primary batteries does have to be replaced. As a matter of fact, the care of the electrolyte in a storage battery is so simple that all it requires is to be left alone, except when the cells are dismantled for sediment cleaning, at which time it may be adjusted, although it would not necessarily be very serious if it were not.

According to the simple theory with which we started, the storage battery consists of two plates of lead immersed in a solution of sulphuric acid and water. During discharge some of this acid combines with the plates, and in this sense it is used up, as in the case of a primary cell, but at this point the difference between a primary cell and a storage battery becomes evident, for whereas the solution has to be renewed in the primary cell, in the case of the storage cell it is driven out of the plates and back into the solution by charging. In other words, it may be considered as replaced in the electrolyte or renewed by charging. Since there is no actual loss of acid from the cell during this process, no actual acid has to be added to the cell to keep it operating.

We operate storage batteries throughout a very wide range of maximum specific gravities, running from something like 1.150 to 1.300, and from this it will appear that there is nothing very magical about any particular point.

Since acid combines with the plates during discharge in direct proportion to the capacity taken out, we have to put enough acid in the electrolyte to take care of the capacity of the cell, with the result that where we are limited as to weight or size, using less electrolyte on this account, we have to cut down the amount of water in the solution, still keeping the full amount of acid. This results in a higher specific gravity at the start of discharge. Higher gravities are used in portable cells and lower gravities in stationary cells where space is no object. Where we are not limited as to space or weight, we decidedly prefer the lower gravities, because these are easier on the plates, whereas if too much acid is put into a cell it may become very injurious.

Actually, as you know, there is a gradual very slight loss of acid from the electrolyte as the cells operate, due to a slight amount of spray being mechanically carried off when the cells are gassing, or to combination with the dead sediment in the bottoms of the tanks, but this loss is so slight that it does not have to be taken into consideration between sediment cleanings, and even where cells operate in specific gravities considerably below what was intended, the effect upon the capacity, and this is the only detrimental effect, is not great, and would probably never be discovered. For example, operating cells in a maximum gravity 50 points below normal would only result in a decreased capacity of something like 10% or 15%, and this would hardly be noticed. In fact, we practically never run into low capacity, due to low gravity, whereas the reverse cannot be said, as we entirely too frequently run into trouble from too high gravity, due to adding acid to the cells when they do not need it.

The important point in connection with the specific gravity is not to have it too strong, not that it should be kept at any particular point, and unless for some very good reason, it is much safer to leave the gravity alone than to attempt to adjust it. Where the specific gravity readings are low, it is much more likely to be due to lack of charge than lack of acid. The low readings are not the trouble, but only the indication of the trouble, and the remedy is not to add more acid, but to give more charge; and the addition of acid at such times is likely to make conditions worse, rather than better.

Hand Book of American Electric Ry. Assn.

The Engineering Manual, published by the American Electric Railway Engineering Association, is now being distributed. This publication is a compilation of the Standards and Recommendations adopted by this association and covers practically the entire field of electric railway engineering. The book is in loose leaf form and consists of 82 sections, fully illustrated with diagrams and working drawings. The loose leaf form of the Manual has been adopted in order that the Standards and Recommendations may keep pace with such additions and alterations as are made at the yearly conventions of the associations. Separate sections may be obtained. The price of the Manual to non-members of the association is $3.00. Binders $1.00 extra. Address Secretary of A. E. R. E. Assn., 29 W. 39th St., New York.

School of Electricity

A Course of Training Prepared by the Pennsylvania Railroad for Its Employees

All back lessons of this course will be furnished at 5 cents each, which will also include, (1) Railroad Electricians' Club, (2) A B C Car Lighting Course, (3) Practical Stunts, and (4) Question Box, as published that particular month.

Lesson No. 14

Mathematics, Whole Numbers

DEFINITIONS.

Arithmetic is the science of numbers and the art of using them.

A **unit** is one, or a single thing; for example, *one*, *one* track, *one* engine, *one* signal.

A **digit** is one of the figures by which numbers are expressed. The digits are 1, 2, 3, 4, 5, 6, 7, 8, 9.

NOTE.—Most authorities do not consider 0 as a digit.

A **number** is a unit or a collection of units; for example, *one* engine, *three* tracks, *five* cars, 45. Numbers may be expressed by words or characters and may be either *concrete* or *abstract.*

An **integer** or integral number is a whole number; for example, 3, 5, 10, 13.

A **concrete number** is a number that is applied to some particular kind of object or unit; for example, *four poles, five switches, seven lamps.*

An **abstract number** is a number that is not applied to some particular kind of object or unit; for example, *two, three, five, ten, 6, 8.*

Like numbers are numbers that consist of the same kind of units; for example, *six tracks, four tracks.*

Unlike numbers are numbers that do not consist of the same kind of units; for example, *three signals* and *five days, six cars* and *eight wheels.*

The fundamental operations in arithmetic are notation, numeration, addition, subtraction, multiplication and division.

NOTATION AND NUMERATION.

Notation is the method of representing numbers by figures or letters.

Numeration is the method of reading numbers which have been expressed by figures or letters.

The **Arabic System** of notation is a method of expressing numbers by figures.

This method uses ten different figures to represent numbers:

Figures	0	1	2	3	4	5	6	7	8	9
Names	naught	one	two	three	four	five	six	seven	eight	nine

The first character, 0, has no value when standing alone, and is called *naught, cipher* or *zero.*

A number expressed by a single figure, as 5, represents the number of units it contains, which in this case is five.

A number expressed by two figures, as 35, means that the *first* figure, counting from the right, represents the number of *units*, which in this case is 5; the *second* figure, counting from the right, represents the number of *tens*, which in this case is 3.

It then follows that a number containing three figures, as 135, means that the *first* figure, counting from the right, represents the number of *units;* the *second* the number of *tens;* the *third* the number of *hundreds.*

In reading a number it is customary to point it off into periods of three figures each, commencing with the right-hand figure, or units. A comma (,) is used to separate these periods.

Trillions.	Hundred billions.	Ten billions.	Billions.	Hundred millions.	Ten millions.	Millions.	Hundred thousands.	Ten thousands.	Thousands.	Hundreds.	Tens.	Units.
				4	7	3	5	6	2	1	3	5

Example:

Read 473,562,135.

Solution:

In pointing off this number, commence at the first figure on the right and count toward the left; thus, *units, tens, hundreds;* insert a comma; *thousands, ten thousands, hundred thousands;* insert a comma; *millions, ten millions, hundred millions.*

The entire number will be read: Four hundred seventy-three million, five hundred sixty-two thousand, one hundred thirty-five.

The **Roman System** of notation is a method of expressing numbers by letters, and uses seven letters of the Roman alphabet. Thus: I represents *one;* V, *five;* X, *ten;* L, *fifty;* C, *one hundred;* D, *five hundred;* M, *one thousand.*

Letters	I	V	X	L	C	D	M
Values	1	5	10	50	100	500	1000

To express other numbers these letters are combined according to the following principles:

1.—*Every time a letter is repeated its value is repeated.* Thus: III represents 3; XX, 20; CC, 200.

2.—*When a letter is placed after one of a greater value, the sum of their values is the number represented.* Thus: XV represents 15; LX, 60; DC, 600.

3.—*When a letter is placed before one of greater value, the difference of their values is the number represented.* Thus: IX represents 9; XL, 40; XC, 90.

4.—*A dash or bar placed over a letter increases its value a thousand times.* Thus: $\overline{\text{V}}$ represents 5000; $\overline{\text{X}}$, 10,000; $\overline{\text{IX}}$, 9000.

ROMAN TABLE.

I	one
II	two
III	three
IV	four
V	five
VI	six
VII	seven
VIII	eight
IX	nine
X	ten
XI	eleven
XIV	fourteen
XV	fifteen
XIX	nineteen
XX	twenty
XXX	thirty
XL	forty
L	fifty
LX	sixty
LXX	seventy
XC	ninety
C	one hundred
CC	two hundred
D	five hundred
DC	six hundred
CM	nine hundred
M	one thousand
MM	two thousand
MCXX	one thousand one hundred twenty
MCMXIII	one thousand nine hundred thirteen

Example:

Express 76 in Roman notation.

Solution:

L = 50; XX = 10 + 10 = 20; VI = 5 + 1 = 6.
Then 76 equals 50 + 20 + 6 = LXXVI.

Example:

Express 725 in Roman notation.

Solution:

D = 500; CC = 100 + 100 = 200; XX = 10 + 10 = 20; V = 5.
Then 725 equals 500 + 200 + 20 + 5 = DCCXXV.

Example:

Read MCLV.

Solution:

M=1000, C=100, L=50, V=5.

Then MCLV would be read one thousand one hundred fifty-five.

ADDITION.

Addition is the process of finding the sum of two or more numbers.

The sign of addition is +, and is read *plus*. It means that the numbers between which it is placed are to be added. For example, 6 + 7 is read, six plus seven, and indicates that 7 is to be added to 6.

The sign of equality is =, and is read *equals*, or *equal to*. For example, 8 + 6 = 14, is read, 8 plus 6 equals 14, and indicates that the sum of 8 and 6 is 14.

Like numbers can be added, but *unlike numbers* cannot. For example, *six cars* can be added to *ten cars*, but *six cars* cannot be added to *eight rails*.

Rule 1:—*To add numbers, place them directly under each other, being careful to place units under units, tens under tens, hundreds under hundreds, thousands under thousands, etc., and draw a line beneath.*

Commence at the right, add each column separately, and write the sum underneath, if it is less than 10.

Example:

What is the sum of 13 + 134 + 241 + 1?

Solution:

Hundreds	Tens	Units	
	1	3	
1	3	4	
2	4	1	
		1	
3	8	9	Sum

Place the numbers so that figures of the same order are in the same column, draw a line under them and commence at the right to add. Add mentally; thus, 1 plus 1 is 2, plus 4 is 6, plus 3 is 9, which is the sum of the figures in the units column. Place the 9 directly beneath this column as the first, or units, figure in the sum. The sum of the figures in the next, or tens, column is 4 plus 3 is 7, plus 1 is 8. Place the 8 directly beneath as the second, or tens, figure in the sum. 2 plus 1 is 3. This is the sum of the figures in the next, or hundreds, column. Place the 3 directly beneath as the third, or hundreds, figure in the sum. The sum is then 389.

Rule 2:—*If the sum of any column is equal to or greater than 10, place the right-hand figure under that column and add the remaining figures to the next column. Write the entire sum of the last column.*

Example:

What is the sum of 3213 + 45 + 365 + 4 + 85?

Solution:

Thousands	Hundreds	Tens	Units	
3	2	1	3	
		4	5	
	3	6	5	
			4	
		8	5	
3	7	1	2	Sum

The sum of the figures in the first, or units, column is 22 units, or 2 tens and 2 units. Place the 2 units as the first, or right-hand, figure of the sum and add the 2 tens to the figures in the tens column. The sum of the figures in the tens column is 19, and when added to the 2 tens carried from the units column, is 21 tens, which equals 2 hundreds and 1 ten. Place the 1 as the second figure of the sum, and add the 2 hundreds to the figures in the next, or hundreds, column. The sum of the figures in the hundreds column is 5 hundreds, which is added to the 2 hundreds, carried over from the tens column, making 7 hundreds. Write the 7 as the third, or hundreds, figure in the sum. There is nothing to carry to the next column because 7 is less than 10. The sum of the figures in the next column is 3 thousands, which will be the fourth figure in the sum. The sum is then 3712.

Proof:—*Begin at the top and add each column downward. If the same result is then obtained as when adding upward, the sum is probably correct.*

SUBTRACTION.

Subtraction is the process of finding the difference between two numbers.

The **minuend** is the *larger* number from which a smaller number is to be subtracted.

The **subtrahend** is the *smaller* number which is to be subtracted.

The **remainder** is the *difference* between the numbers.

The sign of subtraction is −, and is read *minus*. Thus, 8−5 means that 5 is to be taken from 8, and is read 8 minus 5.

Rule 3:—*Place the smaller number, or subtrahend, under the larger number, or minuend, being careful to place units under units, tens under tens, etc., as in addition, and draw a line beneath.*

Commence at the right-hand, or units, column; subtract each figure of the subtrahend from the figure above it in the minuend, and write the remainder beneath.

Example:

What is the difference between 365 and 124, which may also be written 365−124.

Solution:

3	6	5	Minuend
1	2	4	Subtrahend
2	4	1	Remainder

Write the subtrahend under the minuend, placing the units in units column, tens in tens column, and so on. Draw a line beneath, and commence at the right to subtract. 4 units from 5 units is 1 unit. Write the 1 in the units column as the first figure of the remainder. 2 tens from 6 tens is 4 tens. Write the 4 in the tens column as the second figure of the remainder. 1 hundred from 3 hundreds is 2 hundreds. Write the 2 in the hundreds column as the third figure of the remainder. The remainder or difference is then 241.

Rule 4:—*If any figure of the subtrahend is greater than the figure above it in the minuend, add 10 to the latter and then subtract. Subtract 1 from the next term to the left in the minuend and proceed as before.*

Example:

What is the difference between 763 and 479.

Solution:

7	6	3
4	7	9
2	8	4

In this case, 9 cannot be taken from 3, so 1 is borrowed from 6 in the tens column, and added to the 3 in the units column, making 13 units. 9 units from 13 units equals 4 units. Write the 4 in the units column as the first figure in the remainder. Since 1 was taken from 6, there remain only 5 tens in the minuend. 7 tens cannot be taken from 5 tens; so 1 is borrowed from 7 in the hundreds column, making 15 tens. 7 from 15 equals 8, the second or tens figure in the remainder. Since 1 was borrowed from 7 in the hundreds column only 6 remains. 4 from 6 equals 2, the third or hundreds figure in the remainder. The remainder or difference is then 284.

Example:

Find the difference between 6502 and 521.

Solution:

Thousands	Hundreds	Tens	Units	
6	5	0	2	Minuend
	5	2	1	Subtrahend
5	9	8	1	Remainder

1 from 2 equals 1 unit, the right-hand or units figure in the remainder. 2 tens cannot be subtracted from 0 tens; so 1 is borrowed from the hundreds column of the minuend and added to the figure in the tens column. 1 hundred equals 10 tens, which, added to the 0 tens makes 10 tens. 2 from 10 equals 8, the second, or tens, figure in the remainder. Since 1 hundred was taken from 5 hundreds, there remain only 4 hundreds in the minuend. 5 hundreds cannot be subtracted from 4 hundreds, so 1 is borrowed from the thousands column in the minuend and added to the figure in the hundreds column. 1 thousand equals 10 hundreds which, added to the 4 hundreds, equals 14 hundreds. 5 subtracted from 14 leaves 9, the third, or hundreds, figure in the remainder. 1 was taken from the thousands column in the minuend, leaving 5. Since there is no figure in the thousands column in the subtrahend to be subtracted the fourth, or thousands, figure in the remainder is 5. The remainder or difference is then 5981.

Proof:—*Add the subtrahend and remainder together, and their sum will equal the minuend, if the subtraction is correct.*

MULTIPLICATION.

Multiplication is the process of taking one number as many times as there are units in another.

The **multiplicand** is the number to be multiplied.

The **multiplier** is the number showing how many times the multiplicand is to be taken.

The **product** is the result obtained by multiplying one number by another.

The sign of multiplication is ×, and is read *multiplied by*, or *times*; for example, 8 × 5 is read 8 multiplied by 5, or 8 times 5.

TABLES.

1 × 1 = 1	2 × 1 = 2	3 × 1 = 3	4 × 1 = 4
1 × 2 = 2	2 × 2 = 4	3 × 2 = 6	4 × 2 = 8
1 × 3 = 3	2 × 3 = 6	3 × 3 = 9	4 × 3 = 12
1 × 4 = 4	2 × 4 = 8	3 × 4 = 12	4 × 4 = 16
1 × 5 = 5	2 × 5 = 10	3 × 5 = 15	4 × 5 = 20
1 × 6 = 6	2 × 6 = 12	3 × 6 = 18	4 × 6 = 24
1 × 7 = 7	2 × 7 = 14	3 × 7 = 21	4 × 7 = 28
1 × 8 = 8	2 × 8 = 16	3 × 8 = 24	4 × 8 = 32
1 × 9 = 9	2 × 9 = 18	3 × 9 = 27	4 × 9 = 36
1 × 10 = 10	2 × 10 = 20	3 × 10 = 30	4 × 10 = 40
1 × 11 = 11	2 × 11 = 22	3 × 11 = 33	4 × 11 = 44
1 × 12 = 12	2 × 12 = 24	3 × 12 = 36	4 × 12 = 48

5 × 1 = 5	6 × 1 = 6	7 × 1 = 7	8 × 1 = 8
5 × 2 = 10	6 × 2 = 12	7 × 2 = 14	8 × 2 = 16
5 × 3 = 15	6 × 3 = 18	7 × 3 = 21	8 × 3 = 24
5 × 4 = 20	6 × 4 = 24	7 × 4 = 28	8 × 4 = 32
5 × 5 = 25	6 × 5 = 30	7 × 5 = 35	8 × 5 = 40
5 × 6 = 30	6 × 6 = 36	7 × 6 = 42	8 × 6 = 48
5 × 7 = 35	6 × 7 = 42	7 × 7 = 49	8 × 7 = 56
5 × 8 = 40	6 × 8 = 48	7 × 8 = 56	8 × 8 = 64
5 × 9 = 45	6 × 9 = 54	7 × 9 = 63	8 × 9 = 72
5 × 10 = 50	6 × 10 = 60	7 × 10 = 70	8 × 10 = 80
5 × 11 = 55	6 × 11 = 66	7 × 11 = 77	8 × 11 = 88
5 × 12 = 60	6 × 12 = 72	7 × 12 = 84	8 × 12 = 96

9 × 1 = 9	10 × 1 = 10	11 × 1 = 11	12 × 1 = 12
9 × 2 = 18	10 × 2 = 20	11 × 2 = 22	12 × 2 = 24
9 × 3 = 27	10 × 3 = 30	11 × 3 = 33	12 × 3 = 36
9 × 4 = 36	10 × 4 = 40	11 × 4 = 44	12 × 4 = 48
9 × 5 = 45	10 × 5 = 50	11 × 5 = 55	12 × 5 = 60
9 × 6 = 54	10 × 6 = 60	11 × 6 = 66	12 × 6 = 72
9 × 7 = 63	10 × 7 = 70	11 × 7 = 77	12 × 7 = 84
9 × 8 = 72	10 × 8 = 80	11 × 8 = 88	12 × 8 = 96
9 × 9 = 81	10 × 9 = 90	11 × 9 = 99	12 × 9 = 108
9 × 10 = 90	10 × 10 = 100	11 × 10 = 110	12 × 10 = 120
9 × 11 = 99	10 × 11 = 110	11 × 11 = 121	12 × 11 = 132
9 × 12 = 108	10 × 12 = 120	11 × 12 = 132	12 × 12 = 144

NOTE:—These tables should be carefully studied and memorized.

The Railroad Electricians' Club

Meetings the 3rd Monday of Every Month, 8 P. M.—18th Floor Transportation Bldg., Harrison and Dearborn Sts., Chicago—Everybody Welcome—No Dues

Special Meeting for July.

At the July meeting of the Club, Mr. H. H. Smith, of the Edison Storage Battery Company, will give a talk on the characteristics of the Edison Battery. Mr. Smith has been connected with the Edison Storage Battery Company all through the periods of battery development and there is no one better qualified to speak on this subject, aside from Mr. Edison himself, than Mr. Smith.

Meeting will be held Monday, July 20th, on the 17th floor of the Monadnock Building, 8:00 P. M. Everybody welcome.

Review Lesson on Ohms Law

Problem 24—Compare the conductivity of an electric conductor with the conductivity of a water pipe.

Ans. 24. There are many things about the flow of water in pipes that help us to understand electrical circuits. The voltage of a d. c. circuit corresponds to the head of water, or its pressure. Amperes correspond to rate of flow, such as gallons per minute, etc., watts, the measure of power (volts times amperes), correspond to the horsepower of a stream of water flowing through a turbine, which is the gallons per minute times the pressure of the head. The resistance offered to the flow of the electrical current through wires corresponds very nicely with the resistance offered to the flow of water through pipes; the greater the amount of current flowing through the pipe or wire, the greater will be the drop in pressure in each case.

Problem 25—What elements determine the resistance of a wire?

Ans. 25. The resistance of a wire depends upon the material, its area of cross section and its length. It is found that an iron wire or a German silver wire offers much more resistance to the flow of electric current than a copper wire or a silver wire of the same dimensions. Probably no two metals have exactly the same resistance and in fact even the resistance of copper varies greatly, depending upon the amount of impurities in the metal. It is obvious that a big wire will have greater resistance than a small one; a wire of 200 circular mills area of cross section will have only half the resistance per foot of length that a wire of 100 circular mills cross section. Similarly a longer wire will have more resistance than a short wire of the same diameter. 200 ft. of No. 14 copper wire will have twice the resistance that 100 ft. of No. 14 wire will.

Problem 26—What effect has the cross section upon the resistance of a wire?

Ans. 26. This question is covered in the preceding problem. It is self evident that the smaller the wire the less will be its resistance.

Problem 27—What effect has length of a wire upon its total resistance.

Ans. 27. This question is covered pretty well in problem No. 25, the longer the wire the higher the resistance in direct proportion.

Problem 28—What effect does heat have upon the resistance of insulators?

Ans. 28. Heat has a peculiar effect on insulators, which is illustrated by the following example: Take a piece of glass tube, wrap two copper wires around it, about an inch apart, these wires being terminals of a 110 volt circuit. Even with the current turned on, there will, of course, be no current flowing between the terminals as they are separated 1 in. on the glass tube. If the tube is placed in a flame, however, so that it gets hot and softens, the electric current will begin to flow between the copper wires directly through the glass tube and will heat the glass at this point up to white incandescence. This is exactly what occurs in the Nernst lamps, which were extensively used a few years ago. The filament consisted of a small tube of special porcelain which could be heated with an electric coil.

In general it may be said that heat at ordinary air temperatures has little or no effet on insulators, but where this heat gets up near the melting point of glass the insulating qualities are largely broken down.

Problem 29—What is temperature co-efficient of resistance?

Ans. 29. Heat also affects the resistance of metallic conductors and the extent to which the resistance of metals is affected varies with different metals. This is called the "temperature coefficient of resistance." It means the percentage rise in resistance with each degree centigrade rise in temperature. Some metals are much less affected by heat than others, that is, their temperature coefficient of resistance is lower. In fact some alloys have zero temperature coefficient, that is the resistance of metal does not change at all with varying temperatures. It is interesting to note here that carbon has a negative temperature coefficient, that is, its resistance decreases as it warms up and the hotter it gets, the less is the resistance of the carbon.

Problem 30—About how many degrees Fahrenheit change will be required to change the resistance of copper wire by 1%?

Ans. 30. The temperature coefficient of copper at 70° Fahr. is .00387, therefore, a rise of 3 degrees will change the resistance of copper wire by about 1%.

Problem 31—What is meant by line drop?

Ans. 31. The line drop is the number of volts lost in the line. All wire has a certain resistance and it takes a certain voltage to simply force a certain current through this resistance of the line. The more current flowing, the greater will be the line drop, or the voltage consumed in simply causing current to flow through the line. As an example: suppose that we have a line whose total resistance is .2 of an ohm, the voltage at the generator is 220 volts and there is 100 amperes of current flowing. If we consider simply the resistance of the line first, the volts drop will be, according to Ohm's law, voltage is equal to current times resistance, E is equal to (100 times .2 or) 20 volts. In other words, 20 volts will be consumed in simply forcing the current through the line, so that the voltage at the end of the line will be reduced to 200 volts.

Problem 32—What effect does the voltage of a circuit have on line drop, assuming the same wire and power delivered in each case.

Ans. 32. If the voltage of a circuit is doubled, it will require only ½ the current to deliver the same amount of power, that is, 40 amperes at 110 volts represents the same power as 20 amperes at 220 volts. Since the line drop is current times resistance, and if this current is reduced to ½, the line drop will be reduced to ½ also. It should be noted, however, that the percentage line drop of total voltage is reduced to ¼. In other words, if 40 amperes at 110 volts flowing over a certain circuit produces a 4 volt line drop, which is practically a 4% drop in voltage, the 20 amperes on the 220 volt circuit, which is the same amount of power, produces only a 2 volt line drop, which is approximately 1% or ¼ the percentage drop in the first case. This shows the desirability of using high voltages for long transmission lines.

Problem 33—On a 110-volt circuit it is desired to run a line to a 10 h.p. pumping motor 2,000 ft. distant. If the maximum line drop allowable is 10%, what size of wire will be required?

Ans. 33. Here we are allowed a 10% line drop (10% of 110 or) 11 volts. Ten horse power is (10 times 746 or) 7,460 watts. Since watts are current times voltage, the current flowing will be watts divided by volts, or (7,460 divided by 110 or) 68 amperes.

Since we are allowed 11 volts line drop and voltage equals C times R (11 is equal to 58 R), R is equal to 11 divided by 68 or the .162 ohms. In other words, our circuit, which consists of 2 wires each 2,000 ft. long, or a total length of 4,000 ft., must be such as to have a resistance of not more than a .162 ohms total, or .04 ohms per thousand ft. From the wire table in lesson No. 1, under column 9, we find that No. 0000 wire has a resistance of 0.48, which means that a wire the next size larger than No. 0000 will be required. This shows the importance of using high voltages for transmitting power any long distance such as this, for had a 440 volt circuit been employed a wire of 1/16 the sectional area could have been used and still kept within the same percentage line drop.

In figuring wire sizes it is always necessary to refer to the table on allowable currents, table No. 1, lesson No., and here it is found that a No. 0000 wire will carry 312 amperes with weather proof insulator without overheating. So this wire when used on the 68 ampere circuit of this line will not be overheated.

Problem 34—What would be the size of wire required for a 110-volt lighting circuit containing fifty 60-watt lamps, assuming the maximum line drop, or voltage variation, to be 5%. The length of the circuit from the power house to the distributing board is 1,000 ft.

Ans. 34. The fifty-60 watt lamp will consume 3,000 watts, which on a 110 volt circuit would require (3,000 divided by 110 or) 27 amperes. The allowable line drop is (5% of 110 or) 5½ volts and the length of line is (2 times 1,000 or) 2,000 ft.

From Ohm's law we find that volts equals current times resistance. Then 5½ is equal to 27 times R, then (R is 5½ divided by 27 or) .2 of an ohm total resistance allowable in the line in order that the line drop may not go over 5½ volts. Since the total length of circuit is 2,000 ft., this will require wire of a resistance of 1/10 of an ohm per thousand ft. Upon referring to the wire table lesson No. 1, column No. 9, we find that a No. 0 wire has a resistance of .09811 ohms per thousand ft., this wire should be used. If additional lamps are contemplated, a size larger wire should be used.

Upon referring to table No. in lesson No. 1, it is found that with weather proof insulated this wire will carry 156 amperes without over heating. Therefore it will not be necessary to use a wire larger than No. 0 on account of heating of the wire. The line drop, however, limits this to a No. 0 wire or larger.

Problem 35—What size of wire will be used for ten 60-watt lamps from the distributing board in Problem 34 to the lamps? Voltage distance, 100 ft.

Ans. 35. The ten 600 watt lamps will consume 600 watts, which, divided by the 110 volts gives us approximately 6 amperes of current flowing. This distance of 100 ft. is so short that the line drop will not be appreciable and so the heating effect of the wire will be the determining factor in the selection of size of wire. By referring to table No. 1, Lesson No. 1, it is found that a No. 16 rubber covered wire would carry 6 amperes, therefore this wire could be employed as far as heating is concerned. The underwriters' rules forbid the use of any wire smaller than No. 14, so No. 14 wire would have to be used in spite of the fact that both voltage drop and heating would permit of using a smaller wire.

Problems for Next Month

Lead Battery Questions.

Prob. 1. We rate a battery in terms of ampere hours. Most car lighting batteries are of about 300 ampere hours capacity. What does this mean? What is an ampere hour?

Prob. 2. What makes the voltage of a storage battery vary? Why is it necessary to charge at a much higher voltage in the winter time, provided you keep the current constant, than it is in the summer time?

Prob. 3. What is meant by constant current charging?

Prob. 4. What is meant by constant potential charging?

Prob. 5. Why does the gravity of electrolyte of a lead battery go down on discharge and rise on charge, always coming back to the same point at the end of charge?

Prob. 6. What makes the voltage, is it the plates or the electrolyte?

Prob. 7. What is the difference between the pasted type plate and the Plante type plate?

Prob. 8. Can you have a storage battery made up of both pasted and Plante type plates?

Prob. 9. What is meant by the growth or formation of Plante plates?

Prob. 10. Do you have this same growth in pasted plates. If not why not?

Prob. 11. Suppose you take a group of Plante positives and put them into a tank with another group of Plante positives instead of regular negative plates and charge the two. What will happen? Will this make a good battery?

Prob. 12. How do the temperature changes from summer to winter conditions affect the battery voltage on charge and discharge?

Prob. 13. How do temperature changes affect battery capacity?

Prob. 14. What is the highest temperature at which it is safe to operate a lead battery?

Prob. 15. What is normal gravity?

Prob. 16. What are the safe limits for gravity of the the electrolyte?

Prob. 17. Why does temperature affect gravity? Is this of enough importance to be taken into consideration in practical work?

Prob. 18. I read gravity on a cell as 1,240 with the temperature 10 above zero Fahrenheit; is the gravity of the electrolyte above normal?

Prob. 19. Another battery shows gravity of 1,220 at 105 deg. Fahrenheit; is this gravity too high?

Prob. 20. In making up electrolyte for storage batteries how much acid and water do you put together?

Prob. 21. Do you pour the electrolyte into the water, or the water into the electrolyte? What difference does it make, and why?

Prob. 22. Why is it necessary to add water to all cells of the storage battery occasionally?

Prob. 23. What damage will it do if the surface of the electrolyte is allowed to get below the tops of the plates?

Prob. 24. Why do you add just water and not acid?

Prob. 25. Will any kind of water do for flushing batteries?

Prob. 26. What is the mud that collects in the bottom of battery tanks; is it cinders, dust, or lead formation?

Prob. 27. How thick can you let this mud collect before the battery requires cleaning?

Prob. 28. How are you going to find out how thick the mud is?

Prob. 29. Is there any other way you can tell when a battery needs cleaning?

A. B. C. Car Lighting Course

Edited by Edward Wray

The first lesson of this course was published in our Feb., 1912, *issue. All back numbers covering over two years' work can be furnished, bound in heavy paper covers with special binding arrangement, so that future lessons can be added and preserved. This also includes all back lessons of the P. R. R. School of Electricity, the R. R. Electricians' Club, Prize Question Box, and Practical Stunts. Price* $1.00. (*See blank on page* 6.)

Lesson No. 30

The American Headlight Model "D"

There are many points of difference between the headlight to be taken up in this lesson and that of the Pyle National, described in our lesson of May, as will be noted in comparing these lessons. Other makes of headlights and earlier types of the Pyle and the American will be described in later lessons of this course.

The Turbine

The turbine wheel is equipped with two rows of buckets, shown in Fig. 165. These buckets are of special alloy material to make them practically rust proof, and the surface of the bucket is curved in the proper form and is very smooth to decrease friction of steam passing through. The buckets are rigidly held between the two wheel plates, through which the bucket ends pass and are riveted solid. Steam is emitted from an expanding nozzle which transforms the pressure of steam energy into velocity energy so that it leaves the nozzle at the tremendous speed of approximately 2,500 ft. per second. This blast of steam enters at the outer edge of the outer row of buckets and striking against the curved surface of these buckets, is deflected, so that on leaving the buckets it is moving in a reversed direction. Here, however, it strikes the stationary row of buckets, which are curved in the opposite direction from those which rotate, so that the reversed direction of motion of steam as it leaves the outer row of wheel buckets is reversed and when the steam leaves the stationary buckets it again travels in the same direction as it did when leaving the nozzle.

Here it strikes the outer edge of the inner row of wheel buckets and again drives the wheel forward, but in passing through this row of buckets, as in the first row, the curved surface of the buckets changes the direction of the steam so that it travels in the same direction as when leaving the first row of wheel buckets.

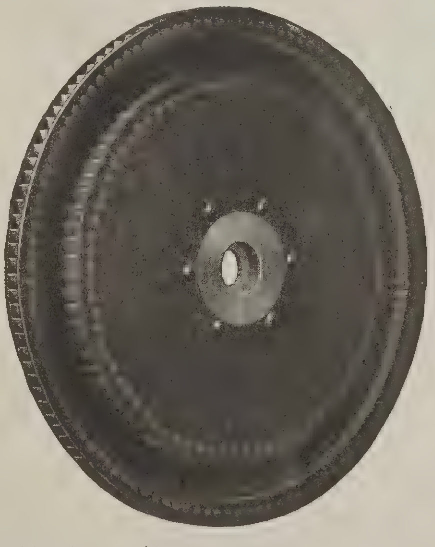


Fig. 165. Turbine Wheel Showing Double Row of Buckets. Steam From Nozzle First Passes Through Outer Row, Then Through Set of Stationary Reversing Buckets Then Through Inner Row of Revolving Buckets.

The nozzle mouth opening covers approximately 4 buckets, so that only 5 of the buckets on the outer wheel are actually driving the turbine at any one instant. On passing through the stationary buckets into the inner row, however, this blast of steam spreads out slightly so that the steam passes through approximately 6 or 7 of the buckets on the inner row at the same instant.

Although the velocity of the steam leaving the nozzle is at the very high speed of 2,500 ft. per second, its pressure is reduced in the nozzle from boiler pressure to atmospheric pressure. Its velocity, however, is gradually reduced as it gives up its energy in driving the bucket wheel, so that on leaving the inner side of the last row of wheel buckets the blast of steam has lost practically all of its velocity and readily finds its way out through the wheel buckets to the exhaust chamber. It should be noted that it is not necessary to have a tight fit between the nozzle and the first row of buckets, or between the stationary and revolving buckets, since the steam, even when it leaves the nozzle mouth is at practically atmospheric pressure and no further expansion takes place and consequently no leakage.

The lineal velocity at which the inner row of buckrow, since it is of a smaller diameter and consequently smaller total length, but, of course, makes a complete revolution in exactly the same time as the outer row. This, however, is no disadvantage since the steam, after having passed through the first row of buckets, has given up a large part of its velocity in causing the wheel to rotate. This steam being redirected by the stationary buckets it impinges the second row of wheel buckets, whose lineal velocity is less than that of the first row passed through, and here the steam imparts energy to the slower moving buckets with more efficiency than if redirected again through the outer row of wheel buckets.

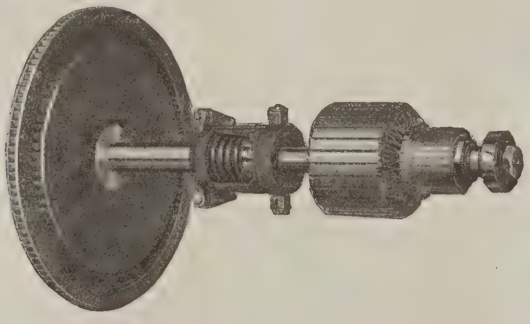


Fig. 166. Turbine Wheel, Governor with Ball Bearing, Armature and Shaft Ball Bearing.

It will be noted upon referring to Fig. 166, that the turbine wheel, the governor and the armature with ball bearings at the armature end are all mounted on the same shaft.

Governor

The governor is of the well-known engine fly ball type in which the balls are thrown outward at a certain angle at normal speed, and if the speed is increased these balls are thrown farther outward, and if the speed is decreased, they close in nearer to the shaft. These governor weights, as shown in Fig. 167, lay in on the spring when the turbine is at rest, as shown in the illustration, but when at normal speed fly outward to a position about parallel with the shaft. These weights are so pivoted that as they fly outward they cause the governor spring to be compressed. The thrust of these weights on the governor cage is transmitted through the large ball bearing shown on the right hand end of the governor, to a set of levers, as shown in Fig. 168, and thence to the balanced valve, opening or closing this valve and increasing or decreasing the steam supply to the turbine wheel as may be required to maintain a constant turbine speed. Accuracy of control is increased by using hardened pins and important rubbing surface to decrease friction, etc.

Governor Adjustment

The speed of the turbine should be about 2,800 revolutions per minute. If it is found to be more than 100 revolutions above or below normal speed, this should be remedied by adjusting the governor spring tension. It will be noted in Fig. 167 that there are two ratchet nuts which bear on the spring. One of these is the main adjusting nut, and the other is the lock nut. If it is necessary to raise the speed of the turbine, loosen the back lock nut and tighten up on the other nut, turning it to the right, so as to increase the pressure of the spring. About ¼ of a turn of this nut will increase the turbine speed 100 revolutions. If it is desired to decrease the turbine speed, turn the governor nut to the left, reducing the pressure on the spring. Be sure to tighten the lock nut securely after the adjusting nut has been properly set.

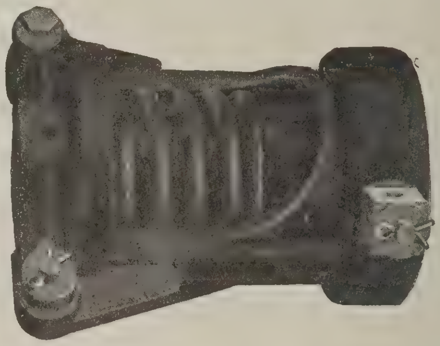


Fig. 167. Fly Ball Type Governor. Note Ball Bearing at Right End.

Bearings

The bearing on the turbine end of the shaft is made of phosphor bronze; it is of liberal dimensions and is provided with a large oil reservoir with ring oiler. Steam condensation in the oil reservoir is automatically disposed of by means of a syphon overflow into the turbine case, the water being heavier than the oil sinks to the bottom and automatically discharges into the turbine case and through the turbine drain pipe, while the quantity of oil is not changed.

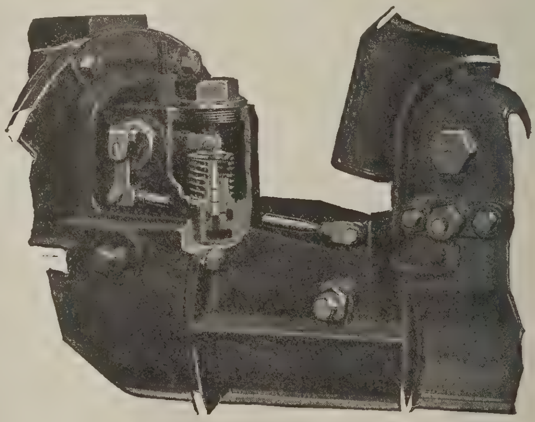


Fig. 168. Part of Case Is Cut Away So As to Show Governor Lever Mechanism.

The generator end of the shaft is supported on a ball bearing, this bearing is shown in Fig. 166. It is mounted on a special sleeve which makes it easy to remove the bearing from the shaft and at the same time provides that a bearing of standard internal diameter be employed. Also, this sleeve serves as an oil throw ring and keeps oil off the commutator.

The Governor Valve

The valve is of the balanced piston type and, as shown in Fig. 168, is operated by the governor weights, acting through a system of levers. When the turbine speeds up above normal the governor moving outward causes the connecting levers to force the valve plunger downward in the valve sleeve; this throttles the steam slightly and reduces the steam supply so that the speed of the turbine is correspondingly reduced and brought down to normal value.

No adjustments of the valve are necessary as the top valve cap causes the plunger to take its proper position in the sleeve. It is important to keep the rod which disconnects the valve arm and the governor yoke as long as possible to take up all lost motion. If there is any lost motion in the levers, the speed variation between no load and full load may be excessive.

In order to determine if the valve plunger works freely in the sleeve, disconnect the valve governor rod and manipulate the valve arm by hand. If the plunger scrapes or sticks remove the top cap and introduce a little valve oil. If it still sticks, remove the plunger and polish off very slightly with fine emery cloth. Great care should be used in doing this, for the valve plunger must make a close fit in the sleeve.

Generator

The generator is a two pole machine of rated capacity of 1 k. w., but is designed to stand considerable overload without excessive heating. The field coils, as shown in Fig. 169, are wound on two large spools, which are mounted on pole shoes supported by two brass feet. These coils are wound so that they both provide a north pole at the same end. The magnetism of the two coils unite in the pole pieces and flow horizontally through the revolving armature. These field coils are compound wound, that is, the magnetism of the coil is generated both by the shunt winding connected directly across terminals of the machine, and by a series winding through which all of the generator current passes. The compound winding automatically compensates for dropping off in voltage as the load increases and maintains the voltage of the generator constant whether the cab lights are used with the headlight or alone.

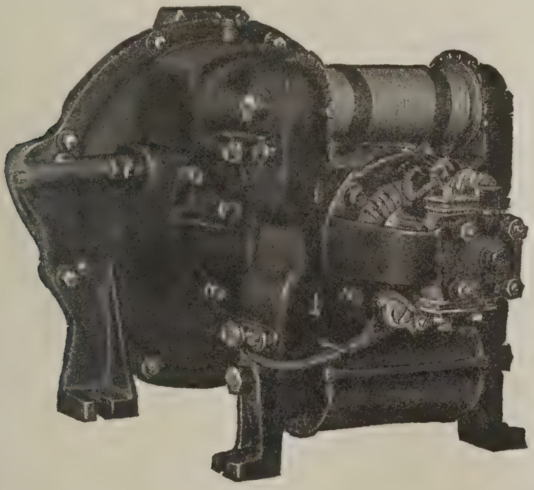
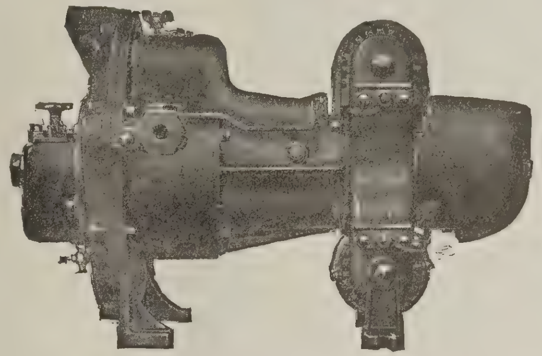


Fig. 169. Commutator End of Generator with Case Removed.

The brushes are given a slight lead, so that they will commutate in the neutral plane when the generator is operating at full load, at which time the armature reaction due to current flowing through the armature coils shifts the magnetic field of the generator slightly, and brings the neutral point of the magnetic field to coincide with the advanced brush position. The armature is of the laminated core type, ring wound construction. That is, the core of the armature consists of a heavy iron ring made up of three discs and supported on the armature shaft by a spider. The wire of each of the coils is threaded through this ring so they do not overlap, as is the case with the ordinary lap or wave wound armature. This makes it easy to replace any one coil, as by unsoldering the ends of the coil from adjacent commutator bars the wire making up this coil can be easily withdrawn after the wedge holding it in place has been removed.



Turbine and Generator Complete.

In this type of generator only that part of the coil on the outside of the armature is effective in developing voltage since there is no magnetic field in the center of the ring where the other half of the armature coils pass. The field pieces of this generator may be easily removed, as all connections to the field coils are made from one side.

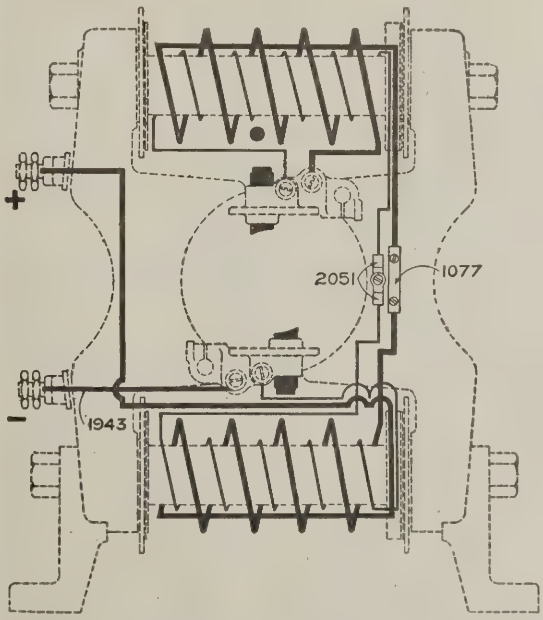


Fig. 169a. Wiring Diagram of Generator Field Connections.

The frame at the commutator which supports the ball bearing at that point is made of cast aluminum. It is, of course, essential that this be made of some non-magnetic material for if it were of iron or steel it would practically short-circuit the magnetic field of the generator and a large portion of magnetic lines instead of passing through the armature where they would be useful in developing voltage, would pass from the north pole to the south pole directly through this generator end bearing frame.

The Arc Lamp

The arc lamp employs the standard carbon copper electrodes, the copper being connected to the negative pole of the generator and the operating magnet is connected in series with the arc, so that all current which passes through the arc must pass through the magnet. The plunger of this magnet connects through a lever to a clutch on the carbon electrode. A spring is provided, the pressure of which opposes the magnetic pull so that a certain predetermined amount of current must be passing through the arc before there will be sufficient magnetism developed in the solenoid to cause this plunger to move, having overcome to a certain extent the pressure of the spring. This spring is shown mounted horizonatally at the top of the frame of the lamp, Fig. 170, and an adjustable thumb screw is provided so that the current through the arc lamp may be adjusted to proper value. If the current through the arc lamp tends to rise above normal it will pull down on the plunger and raise the carbon electrode, thus lengthening the arc, increasing its resistance and reducing the current through the arc to normal value.

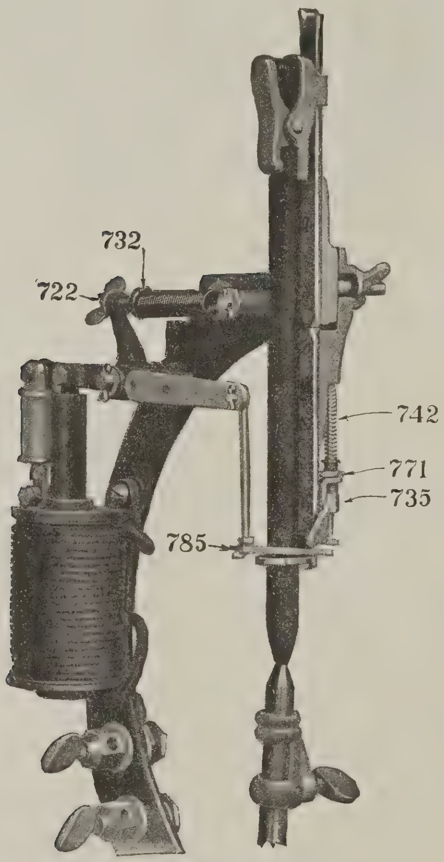


Fig. 170. Showing Construction and Operating Magnetism of the Arc Lamp.

In adjusting the feed mechanism of the lamp, turn off the current and release all pressure of the little back spring on the clutch. After having the top spring so as to bring the plunger and mechanism back to a position so as to allow the carbon to flow freely through the clutch, turn on the current. The lamp may chatter, due to the plunger jumping; if this occurs, shorten the back spring so as to increase the pressure of the foot on the clutch sufficient to cause the clutch to grip the carbon when the current is passing through the lamp and the plunger is pulling downward.

The object of the little back spring is to keep the clutch at a gripping position and to prevent the carbon from crawling with the vibration of the locomotive.

Focusing the Lamp

As explained above, the positive electrode of a direct current arc lamp gets very much hotter than the negative electrode and even where both electrodes are carbons, the positive wears away very much faster than the negative. Since the negative electrode in headlight service is made of copper and copper does not oxidize nearly as readily as carbon, the negative electrode in this case will not wear away to an appreciable extent unless the current through the arc lamp rises to an excessively high value. This causes light to have a green color, because of the fact that excessive heat volatilizes the copper electrode and the copper fumes at high heat in the arc flame produce a green light. Normally, however, practically all of the light is generated at the positive electrode, which, as explained above, reaches an intense white heat.

The paraboic reflector, such as is used in headlights, requires that the source of light be exactly at the center of the lamp in order to produce a parallel beam of light. The position of the focal center of the reflector varies with the different sizes and types of reflectors. The following table gives the distances which the point of the electrode should be from the back of the reflector:

18 in. dia. by 8¾ in. deep, 2 3/16 in.
18 in. dia. by 9 in. deep, 2¼ in.
18 in. dia. by 10½ in deep, 1⅜ in.
18 in. dia. by 12 in. deep, 1¾ in.

Since the light actually comes from the positive carbon electrode instead of the negative copper one, the tip of the copper electrode should be set about ⅛ of an inch below the actual center. This will bring the tip of the carbon electrode at approximately the focal center.

In adjusting the lamp, the reflector should be set so that it stands square with the case. The frame of the arc lamp should then be set so that its back edge is parallel with the back edge of the reflector base and the carbons the proper distance from the back of the reflector.

With the locomotive of a straight track turn on the current and perfect the position of the electrodes so that the reflected light is in a parallel beam down the center of the track. Then tighten the hand wheels and all other screws on the lamp. The arc should never be thrown out of focus in order to bring the beam of light to the center of the track. This should always be done by shifting the reflector.

In polishing the reflector, always run back and forth, but never in a circular direction, as this will have the same effect as sandpapering wood across the grain; it will appear very scratchy and reduce the efficiency of the reflector.

Wiring System

It is advisable to so wire the locomotive that the engineer can have a high or low power light, or no light at all by use of a single pole double throw switch mounted conveniently.

July Meeting of R. R. Electricians Club.

Don't forget the July meeting of the R. R. Electricians' Club. It's important. Mr. H. H. Smith, Mr. Edison's right hand man, will speak on the Edison battery. 17th floor, Monadnock Bldg., Jackson and Dearborn Sts., Chicago. Tell your friends.

Prize Question Box

This "Question Box" is open to every electrical man in the Mechanical, Signal and Telegraph, as well as Car Lighting Departments. We feel that this can be made a mighty valuable thing, so as a special inducement to the boys to boom it, we offer prizes for the best questions asked, as follows:

First prize ....$1.00 *in cash*
Second prize ....9 *months' subscription*
Third prize ....6 *months' subscription*

There are some questions that are of a general nature, which should have comments of prominent men of experience. These will be published under "Questions Before the House," and we hope that prominent railroad men and manufacturers will discuss these questions. All answers published will be paid for at $1.00 each.

Questions Before the House

Current in Moskowitz System.

No. 4. Why does the current run up on a Moskowitz equipment as the speed of the train increases? That is, if the dynamo is set for 30 amperes when the train is running at 30 miles an hour and when the speed of the train increases to 50 miles per hour, you will find that the output of the machine has raised almost double, to perhaps 45 or 50 amperes.—A. E. Voigt.—Santa Fe.

Water for Flushing Batteries.

No. 6. Why do battery manufacturing companies prescribe that only absolutely pure distilled water must be used for flushing the cells, when if pressed they will all admit that it is permissible to use Lake Michigan water? Is this water of equal purity with distilled water?—J. L. Ohmans, Elec. Fore., C. & W. I. Ry.

System of Handling Repairs to Axle Equipment.

No. 7. What is the best method of handling repairs to axle devices? That is, is it better to make repairs on each device enroute or at terminals as soon as the trouble develops or, by having a few spare equipments, simply replace the complete board or the complete generator which is giving trouble and make the necessary repairs in the shop?—L. S. Billau.

Ampere Hour Meters in Car Lighting Service.

What attention has it been found necessary to give ampere hour meters in car lighting service to maintain them properly? How frequently should they be removed from cars and taken into shop for thorough overhauling?—L. S. Billau, B. & O. Ry.

Voltage of Edison Batteries.

Is the voltage of the Edison battery affected by standing idle for a few days in extremely cold weather?—G. B.

Ground on Type "K" Relay.

What effect will a ground on a type K relay have on the operation of the U. S. L. equipment?—Frank M. Burke. Pullman Co., Jersey City.

Scale on Battery Bridge.

Q. After a battery has been in service for 3 or 4 years and a plate breaks off from either group and you try to burn another plate on with an arc, I have found that a scaly hard substance is deposited on top of the bridge, which the arc will not penetrate, while on the under side of the bridge there is no such hard scale and an 8 volt arc will easily deliver 160 amperes. Why does this scale exist on the top of the bridge and not on the under side? What is it composed of, and what causes it to form?—E. J. Galloway, Oakland, Calif.

A Problem for the Axle Light Man.

Assume we have a constant current regulator set for 40 amperes, 30 amperes lamp load turned on, and a carbon pile lamp regulator set for 31 volts, with the lamp regulator so designed that it would maintain this voltage even to the point of opening its own main stack of carbons. With the equipment operating under these conditions, what would happen if the battery circuit opens. L. D. Smith, Rock Island Lines, Chicago, Ill.

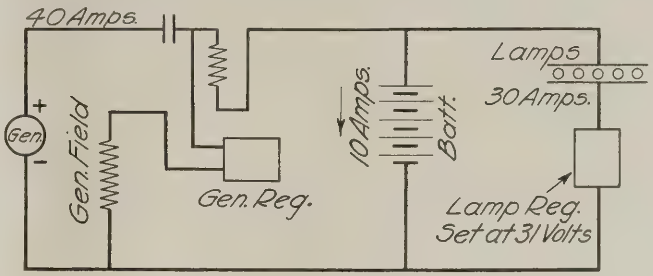


Diagram to Illustrate Axle Lighting Problem.

First Prize

Field Fuse Trouble.

No. 3. On Bliss equipments I find that the shunt fuse will almost invariably blow if the automatic switch does not close or if there is an open in the battery circuit. But on the Moskowitz type of equipment I quite often find that the automatic switch does not close and yet the shunt fuse does not blow as it would in a Bliss equipment. Will you try to furnish an explanation?—S. W. Everett, Santa Fe.

Upon referring to the accompanying diagram it will be seen that the Moskowitz system is radically different from the Bliss system in this respect: whereas in the Bliss system a carbon resistance is placed directly in series with the field, in the Moskowitz system the carbon resistance is placed in parallel with the field and a resistance of about 5 ohms is connected between the field and carbon pile combination and the generator terminals.

When the automatic switch fails to work with the Bliss system, the carbon pile is tightly compressed and of low resistance. Therefore, the field current rises to a high value when the voltage goes up above normal.

With the Moskowitz system on the other hand there is a resistance of about 5 ohms permanently in series with the field, and this, with no pressure on the carbon pile, will give a total resistance of about 9½ ohms. This circuit is fused at 10 amperes and accordingly to Ohm's Law, volts equals current times resistance (E=C×R), it will require a voltage of 95 volts to force 10 amperes through the circuit. Since the 30 volt machine rarely attains a speed sufficient to produce a voltage as high as this, it is very evident that a 10 ampere fuse will be able to indefinitely carry the field current when an open battery circuit occurs.—M. F. Hand, Santa Fe R. R., Topeka, Kans.

Second Prize

Weak Cells in a Battery.

In testing out batteries which are in a partly discharged condition, it happens that one or more cells show a reversed polarity when the test is made with load on the batteries. After disconnecting the reversed cells, however, they show a weak voltage in the right direction. Are the cells so affected actually reversed, or is the internal resistance of the cells so high that current goes through the voltmeter in the wrong direction when the cells are in circuit with the set?—W. M. Wiggins, Pullman Co., St. Louis.

It is not safe to consider a storage battery as a simple resistance for there is always the element of an electromotive force which must be considered. Even though a cell may show reversed polarity, if it is disconnected and allowed to stand for a few moments it may recover and show correct polarity as you speak of. This is because of the fact that although active material on the surface may have been of the wrong polarity, when the cell is allowed to stand, the active material below soon overcomes the effect of the surface material and restores normal polarity.

The high resistance of the reversed cell does not enter into the problem at all, in fact, the resistance of the cell may be almost as low as when fully charged. At any rate, regardless of what the relative resistance of volt meter and battery meter were, the meter would always read in the same direction. The electro-motive force above mentioned, however, causes it to show reversed when such conditions occur.

Third Prize

Reversal of Battery Cells.

Why will one or more cells in a battery become reversed without any apparent cause for so doing?—Z. Humphrey, Santa Fe, San Bernardino, Calif.

It must be remembered that in a lead battery of the Plante type the plates are originally both the same consisting simply of rolled sheet lead. Both are formed as positive plates and later some are reversed to form negatives, so that when a cell becomes completely discharged the plates are practically identical.

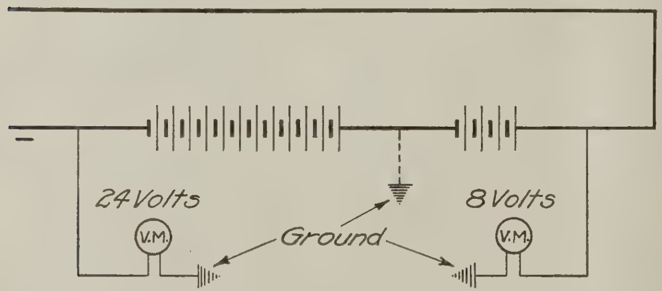
If this completely discharged cell happens to be connected in series with a number of other cells in fairly good condition and which are connected to lamps or other load so that a discharging current flows, this current flowing through the cell which is now completely dead will act as a charging current in that cell and tend to charge it up again, but in the wrong direction. It is usually found that when any one cell in a battery shows a voltage much lower than the others, there is some short circuit or other cause of local discharge in that particular cell, such as lead tree, deep sediment copper or iron in the electrolyte, etc. When this source of trouble is removed and the cell charged up again, there should be no further trouble.

Practical Stunts

We Pay a Dollar Apiece for Practical Stunts—Send in Your Ideas

Locating Grounds on Storage Battery

Where a ground on a storage battery is fairly heavy so that the resistance to ground is very low in comparison with the resistance of the voltmeter, this ground can be located easily with a voltmeter. By referring to the accompanying diagram, we'll assume that we have a ground somewhere on the battery. By connecting the voltmeter from the negative to ground, we get 24 volts, and by connecting from positive to ground and reversing terminals we get an 8-volt indication. This would show that the ground on the battery was in the second or third tank from the positive end. If it shows 16 volts in each case it would indicate that the ground was at about the middle tray of the battery, etc.—Otto Hildebrand, Edison Storage Battery Co.



Illustrating How Grounds on Battery May Be Located.

Tension Rod Clamp Stunt

On the Bliss axle dynamo suspension there is a tension rod clamp used which sometimes does not grip the dynamo loop tight enough to hold it in position. Various methods have been used to tighten this, such as putting half of a cotter key or a piece of tin under the clamp.

I find that a quick and easy method of tightening this clamp is to take it off and lay in on the rail and hit it with a hammer on the convex side, straightening it enough so that it will come tight on the loop before it binds on the tension rod. After tightening a large number in this manner I find that they will hold satisfactorily.—W. C. Burgess, Santa Fe, Los Angeles, Calif.

Home Made Brushes.

Sometimes brushes with pig tails are not available, but temporary brushes can be made in the following way, which will serve the purpose until proper brushes arrive.

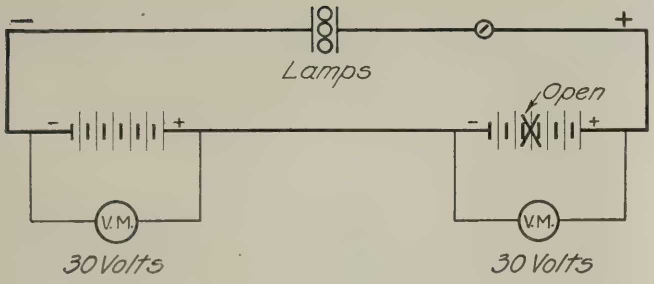
Take an ordinary carbon brush of the required size, or saw out a piece of bulk carbon and drill a hole in the top of the brush for a tap. If a tap is not handy, simply take an ordinary screw and file off the threads on two opposite sides, this will make a rough tap, which, with a little care, will cut its own thread into the carbon. Place a pig tail under the head of the screw and tighten; then solder pig tail to screw and copper plate the whole business by simply placing in a copper sulphate solution and connecting the brush to the negative pole of the battery. Copper plating the surface will decrease the resistance of the brush.

J. R. Pratt, Elec. Fore., M. K. & T. Ry.

Testing for Open Battery Circuit

Of course the way to locate an open circuit in a battery is to simply test in on each tank with a voltmeter. You will get a voltage indication on all tanks except the one where the open circuit is located, there you will get no voltage.

I had an interesting case of trouble along this line



A Peculiar Case of Trouble Due to Open Battery.

recently, however, in trying to locate an open circuit on a 60-volt battery. Since the battery was mounted in two different boxes, half in each box, I tested out the terminals of each half battery to determine which half battery the open circuit occurred in. In each case I got a 30-volt reading, indicating the circuit was complete, still the lamps would not light. I finally found that someone had turned on a lamp circuit, so that when I read across the dead half of the battery I was simply reading the voltage of the good half a second time, connection being made through the lamp circuit. This is clearly shown in the accompanying illustration.

When the lamp circuit was cut off the dead half battery and the dead cell were easily located with a voltmeter.—Otto Hildebrand, Edison Storage Battery Co.

With the Manufacturers

L. R. POMEROY.

L. R. Pomeroy, a railway and electrical engineer of prominence, has been appointed manager of the New York Sales Office, 16-24 W. 61st St., of the U. S. Light & Heating Co., the general offices of which are now at Niagara Falls, N. Y. Mr. Pomeroy has under his direction the sales of the U-S-L axle electric car lighting equipment, U-S-L electric starter and lighter, and U-S-L storage batteries, in the territory of the New York branch office.

L. R. Pomeroy.

Mr. Pomeroy has long been engaged in work in the railway and electrical fields, and enjoys the reputation of being an authority along several lines in each industry. He was born at Port Byron, N. Y., in 1857, and attended high school at Milwaukee, Wis., and the Irving Institute, at Tarrytown, N. Y. From 1874 to 1880 he was engaged in commercial business, bookkeeping, special auditing, drafting and designing of cars and locomotives. From 1880 to 1886 he was secretary and treasurer of the Suburban Rapid Transit Company, of New York. For four years following this he was a special representative of the Carnegie Steel Company, introducing basic boiler steel for locomotives and special forgings for railways. For nine years he was engaged in the same work with the Cambria Steel Company and the Latrobe Steel Company, jointly; this assignment involved metallurgical engineering and experimental research to adapt special steels for railway axles, crank pins and piston rods. From 1899 to 1902 he was assistant general manager of the Schenectady Locomotive Works. For six years following this he was a special representative in the railway field for the General Electric Company, this work covering the electrification of steam roads, railway shops, and the general application of electricity for all railway purposes. Following this he was for two years assistant to the president of the Safety Car Heating & Lighting Company, during which period he devoted a portion of his time to consulting work in the special field or railway shops and machine tool operation. From the Safety Co. he went with J. G. White & Co., New York, as chief engineer of the railway and industrial division. Before becoming associated with the U. S. Light & Heating Co. he had an office at 50 Church St., New York, and served a large clientele as consulting engineer.

The Fundamental Principles of the E. S. B. Axle Lighting System.

This is the title of a new bulletin No. 144, just issued by the Electric Storage Battery Co., which describes in considerable detail the fundamental principles of the E. S. B. axle lighting system. The bulletin discusses in considerable detail the matter of constant potential charging and shows that a lead storage battery made up of Manchester positives and shelf negatives can be charged to full capacity on a voltage of 2.25 volts per cell. For an equipment of 16 cells a voltage between 35 and 36 volts maintained at the battery terminals when the dynamo is in operation, is sufficient.

Some interesting facts regarding the operation of the E. S. B. equipment installed on the Santa Fe in November, 1912, are given. This equipment has a record of 18 months' service, total mileage 268,000 miles with no light failure and no delay in car service on account of axle lighting equipment and no repairs to the dynamo except replacing a defective ball bearing, which was smaller than the present standard 412 size. It has been found on this equipment that it is necessary to flush the battery only twice a year.

Copy of this bulletin will be forwarded to any of our readers upon application to the Electric Storage Battery Co., Philadelphia.

The House

25 years of specializing in the supply of electrical equipment
portant factor in railroad work. Your entire requisition
can be covered with one order and you receive the goods
"House of Service" serve you.

Alexalites

With the extensive application of Mazda lamps in railway service it is very important that all lamps be carefully screened or concealed. The **Alexalite** conceals the light source and insures **safety, comfort** and **economy** in passenger service.

Write for information.

OKONITE

TRADE MARK.

Insulated wire for railway signals, car lighting and power service must be absolutely dependable and have the highest insulating qualities. For years Okonite has been the standard insulation in railroad service. Okonite Insulation contains never less than 30% dry, fine, up-river Para rubber and is made in but **one grade only—THE BEST.**

Central Elect

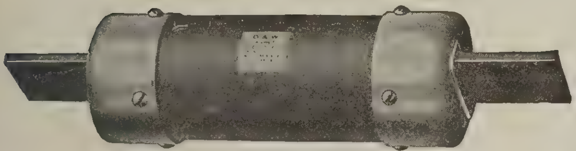
The House

320-326 S. Fifth Ave.

# of Service

for railroads has made "Central Electric Service" an im-
for electrical equipment on any job, no matter how large
in one shipment! Think of the convenience! Let the

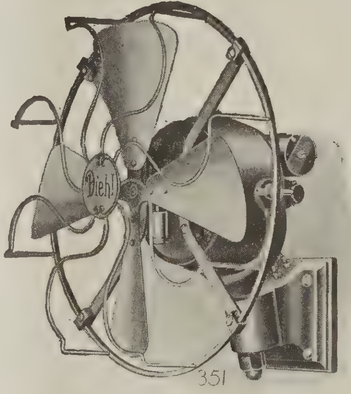
D & W Fuses



D & W Non-Arcing Refillable Fuses

save 65 per cent of your fuse expense—they are refilled at small cost. You can tell a D. & W. Fuse at a glance; it is different; ampere capacity stamped in fibre; safe indicator; no metal exposed; extra heavy caps and tubing and perfect alinement of soldered blades.

Diehl Car Fans



give a finishing touch to passenger comfort. Designed specially to meet the severe conditions of this service. The fan body is readily removed from the base without disturbing the wiring. Pleasing in design.

ric Company

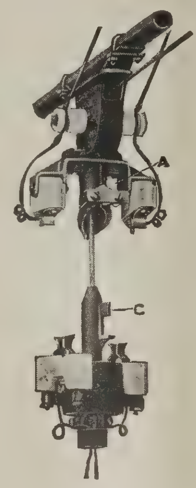
of Service

Chicago

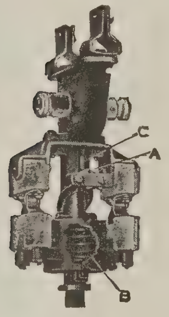
Single Rope Automatic Cutout Lamp Hanger

A recent development in lamp hangers have been made by the Thompson Electric Co., which will interest all railroad electrical engineers who have large lamps to maintain in shops, stations, yards, etc. This hanger requires but a single cord so that no takeup reel device is required. Its construction is clearly shown in the accompanying illustrations and it will be seen that electrical connection is made by two simple knife contacts which are forced together by a substantial spring (B) when the hanger is pulled into position. In the operating position the hanger is secured by the pawl "A," but when it is desired to lower the lamp, a pull on the rope further compresses the spring "B," and raises the pawl "A" so that after pulling and giving a quick release, as in operating a spring window shade, the pawl "A" is thrown back out of the catch "C" and allows the lamp to be lowered.

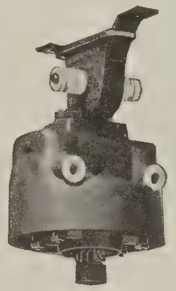
On raising the lamp to the operating position it is only necessary to pull it up as far as it will go and release it slowly, thus allowing the pawl "A" to follow into place and engage the catch "C." When the lamp is lowered it is entirely cut out of circuit and there are no connecting wires whatever. In this day when the importance of keeping lamps and reflectors clean is being appreciated more than ever before, the value of this single cord cutout hanger is at once evident.



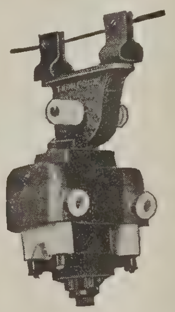
Hanger Being Lowered.



Hanger In Place with Cover Removed.



Housing for Exterior Mounting.



Housing for Interior Mounting.

Steel Tape Armoured Cables.

This is the title of a booklet recently issued by the Standard Underground Cable Co., which describes in detail steel armoured cable, 2 way and 3 way joint boxes, terminals, etc. Copy of the bulletin may be had upon application to the Standard Underground Cable Co., Pittsburgh.

Hess-Bright Ball Bearing Booklets.

Hess-Bright Mfg. Co., have recently issued a new booklet on ball bearings for axle car lighting generators. The booklet gives much information on the subject of ball bearings, lubrication, etc., and should be in the hands of every car lighting man. An interesting statement in the bulletin is that there are at the present time over 3,000 car lighting generators equipped with Hess-Brights. Bearings are now lubricated only once in 6 months.

A copy of this bulletin may be had upon application to the Hess-Bright Mfg. Co., Philadelphia.

Committees

of the Association of Railway Electrical Engineers

Semi-Annual Convention will be held at Atlantic City, Friday, June 12th, Headquarters Hotel Dennis. Annual Convention October 19th to 23rd, at Chicago.

PRESIDENT

C. R. Gilman, C., M. & St. P. Ry.

SENIOR VICE-PRESIDENT

H. C. Meloy, L. S. & M. S. Ry.

JUNIOR VICE-PRESIDENT

E. W. Jansen, Ill. Cent. Ry.

SECRETARY-TREASURER

Jos. A. Andreucetti, C. & N. W. Ry.

EXECUTIVE COMMITTEE

C. J. Causland, Penn. R. R. Lines East.
L. S. Billau, B. & O. R. R.
Wm. A. Del Mar, N. Y. Central.
A. J. Collett, Union Pac. Ry.
N. E. Lemmon, Pullman Co.
J. J. Hack, So. Pac. Co.

COMMITTEE ON AXLE EQUIPMENT.

H. R. Bucks, Chairman, Chief Elec., Oregon Short Line.
Geo. W. Murrey, Chief Elec., S. P. L. A. & S. L. Ry.
E. M. Cutting, Edison Storage Battery Co.
N. E. Lemmon, Elec. Eng., Pullman Co.

COMMITTEE ON DATA AND INFORMATION.

B. F. Bilsland, General Electric Co.
C. J. Causland, Pennsylvania R. R.
George W. Cravens, Cravens Electric Company.
W. A. Del Mar, Asst. Elec. Engr., N. Y. C. Line.
A. J. Farrelly, C. & N. W. Ry. Co.
J. E. Gardner, C. B. & Q. R. R.
W. M. Wiggins, Elec. Insp. Pullman Co
Edward Wray, Chairman, *Railway Electrical Engineer.*

COMMITTEE ON ELECTRIC TRACTION

H. M. Van Gelder, Chairman, Westinghouse, Church Kerr & Co.
J. H. Davis, Elec. Engr., B. & O. R. R.
D. C. Woodbury, N. Y. C. & H. R. R. R.
Paul Real, Ass't Engr., N. Y., N. H. & H. R. R.
Chas. P. Kahler, Elec. Engr., Oregon Short Line R. R.
C. B. Keiser, M. M., Penna. Lines East.

COMMITTEE ON ELECTRIC HEAD LIGHTS.

Chas. R. Sugg, Chairman, Elec. Eng., Atlantic Coast Line R. R.
Geo. E. Murrey, Chief Elec., Chicago Shops, C. & N. W. R. R.
J. J. Hack, Eng. Tr. Ltg., H. & V. Southern Pacific R. R.
Jno. E. Gardner, Elec. Eng., C., B. & Q. R. R.
L. C. Hensel, Chief Elec., St. Louis & San Francisco R. R.

COMMITTEE ON HEAD END EQUIPMENT

S. K. Hare, Ch. Elec., Nor. Pacific R. R.
Jos. A. Andreucetti, C. & N. W. R. R.
A. J. Collett, Elec. Engr., Union Pacific R. R.
E. W. Humphrey, Ass't Elec. Engr., Great Northern R. R.
C. R. Gilman, Chief Elect., C., M. & St. P. R. R.

COMMITTEE ON ILLUMINATION

L. S. Billau, Chairman, Elect. Dept., B. & O. R. R.
J. L. Minick, Chief Draftsman, Penna. R. R.
H. C. Meloy, Chief Elect., L. S. & M. S. R. R.
L. Schepmoes, Safety Car Heating & Lighting Co.
D. P. Morrison, Elec. Engr., P. & L. E. R. R.
W. H. Rolinson, Westinghouse Lamp Co.
Preston S. Millar, Electrical Testing Laboratories.
C. W. Bender, National Elec. Lamp Association.

Sub-committee on Lamp Specifications.

J. L. Minick, Chairman,
J. R. Sloan,
Henry Rogers.

COMMITTEE ON LOOSE LEAF BINDERS FOR FILING SPECIFICATIONS AND TO KEEP SPECIFICATIONS AND STANDARDS TO DATE

J. R. Sloan, Chairman, Eng. Elec. Tr. Ltg., Penna. R. R.
J. L. Minick, Chief Draftsman, Penna. R. R.
T. V. Buckwalter, Draftsman, Penna. R. R.

COMMITTEE ON OUTSIDE CONSTRUCTION AND YARD LIGHTING

H. M. Warren, Chairman, Elec. Engr., D., L. & W. R. R.
W. H. Keirn, Elect., Penna. R. R.
Jos. A. Andreucetti, Gen'l Fore., C. & N. W. R. R.
C. J. Causland, Chief Elect., Penna. R. R. Lines West.
C. D. Axtell, Gen'l Fore., D., L. & W. R. R.
J. L. Minick, Penna., R. R.

COMMITTEE ON ORGANIZATION OF YARD FORCES

C. B. Keiser, Chairman, M. M., Penn. R. R.
W. C. Kershaw, Elec. Fore., Pa. R. R., New York, N. Y.
L. L. Newman, Supr. Elec. Car Ltg., Pa. R. R.
D. J. Cartwright, Elec. Engr., Lehigh Valley R. R.

COMMITTEE ON RECIPROCAL RELATIONS

L. S. Billau, Chairman, Elec. Dept., B. & O. R. R.
J. R. Sloan, Eng. Elec. Tr. Ltg., Penna. R. R.
Jos. A. Andreucetti, C. & N. W. R. R.

COMMITTEE ON RUBBER BELTING

J. R. Sloan, Chairman, Engr. Elec. Tr. Ltg., Penna. R. R.
Jno. M. Craig, Supr. Elec. Tr. Ltg., Penna. R. R.
J. P. Puette, Ass't Chief Elect., Penna. R. R.

COMMITTEE ON SHOP PRACTICE

Geo. W. Cravens, Chairman, Manager Welding Apparatus Deparment, C. & C. Elec. & Mfg. Co.
R. F. Moon, Westinghouse Electric & Mfg. Co.
G. M. Crownover, Supt. M. P., Chicago-Great Western Ry.
L. C. Hensel, Chief Elec., St. Louis & San Francisco Ry.

RAILWAY ELECTRICAL ENGINEER

Official Journal
of the Association of Railway Electrical Engineers.
PUBLISHED MONTHLY BY
WRAY PUBLISHING CO.
EDWARD WRAY,
President.
800 ADVERTISING BLDG.—123 W. MADISON ST.
CHICAGO.
Telephone, Randolph 7414.

Entered as second-class matter, August 6, 1909, at the Post Office at Chicago, Ill., under the Act of March 3, 1879.

TERMS OF SUBSCRIPTION
United States, Canada and Mexico . . . Per Year, $1.00
Foreign ....Per Year, $1.50

OUR OBJECT.

The object of this publication is to provide a medium for the free interchange of ideas and experience among those identified with the operation of electrical apparatus as applied to railway practice.

In this mutual exchange of ideas among the men prominent in the field there will result a better understanding and solution of the problems before us and a wonderful inspiration for all to greater achievements.

CONTENTS

Page
Page

Editorial:
- Better Bearings for Car Fans 69
- The Gas Filled Mazda 69
- The Annual Convention 69

The Electric Locomotive in Switching Service 70
The Development of the Gas Filled Mazda 73
Auxiliary Trucks for 2,400-Volt Electric Locomotives 75
The Edison Storage Battery, H. H. Smith 79
Questions on the Edison Battery 82
Penn. R. R. "School of Electricity," Lesson No. 15, Mathematics (Continued) 86
The Railroad Electricians' Club—Lead Storage Battery Questions 89
A. B. C. Car Lighting Course, Lesson No. 31, Type "L" Consolidated Axle Equipment with Ampere Hour Meter Control 91
Prize Question Box 93
Practical Stunts 95
Summer Vacation Section 97
General News Section 98
New Type Car Ventilating Fan 99
Association Directory 100

The Gas Filled Mazda

We have become so accustomed to radical developments in incandescent lamps, with the gem, tantalum and tungsten lamp developments coming in rapid succession, that the recent advent of the gas filled mazda, giving light at about twice the efficiency of the vacuum type tungsten or mazda lamp is taken more as a matter of course and there is little appreciation of the vast amount of research work which lies back of this wonderful lamp.

Mr. C. L. Dows in this issue gives us an idea of some of the labors involved in this development. He states that although at the present time the 400 watt lamp is the smallest size made for regular multiple service, a lamp of smaller size may soon be available. For many classes of service, such as lighting the approaches to stations, yard lighting, and certain classes of shop and freight house lighting, where the use of large units is not permissable, the series gas filled mazda should find an extensive application.

For its most efficient operation the filament should be operated at about 20 amperes. This current on a 110-volt circuit, representing over 2,000 watts, would give over 4,000 candle-power, which, of course, would be out of the question in most cases. Low voltage lamps, employed either by placing several in series or by employing a low voltage transformer or a compensator on the lamp, would make it possible to use this lamp at its most economical current rate and at the same time permit of lighting units being of reasonably low candle power.

Annual Convention Arrangements

Arrangements have been practically completed for the coming convention of the Association of Railway Electrical Engineers, LaSalle Hotel, Chicago, October 26-30th. The entire 19th floor of the LaSalle Hotel will be used for convention exhibits and the meetings of the A. R. E. E. will be held on the floor below.

The entertainment features will include an informal reception and opening dance in the East room of the hotel Monday evening, October 26th. The usual matinee theatre party for the ladies will be given probably Wednesday afternoon, but the automobile trip will be omitted this year because in past years it has been found that this trip was rather disagreeable for the ladies on account of the lateness of the season.

The annual banquet will be omitted this year and in place of it there will be given a dinner dance in the large ball room on the 19th floor, Friday, October 30th. The exhibits will be closed at noon that day in order to allow sufficient time for their removal.

The following committees have been appointed:

Exhibits:
Wm. F. Bauer, Edison Storage Battery Co., Chairman; J. J. Hack, Southern Pacific Co.; L. C. Hensel, Frisco Lines; Ward Barnum, L. & N. R. R.; Geo. Graber, Kerite Ins. Wire & Cable Co.; Walter Fagin, Crouse-Hinds Co.

Auditing:
J. M. Lorenz, Central Electric Co., Chairman; W. E. Ballantine, Willard Storage Battery Co.; J. A. Andrucetti, C. & N. W. R. R.

Badges:
J. Scribner, General Electric Co., Chairman; J. A. Andrucetti, C. & N. W. R. R.

Entertainment:
A. C. Moore, Safety Car Ltg. & Htg. Co., Chairman, assisted by the following sub-committees:

Opening Dance:
Otis B. Duncan, Geo. Cutter Co., Chairman; E. W. Jansen, Ill. Cent. R. R.; C. J. Causland, Penn. R. R.; H. E. Watson, Benjamin Elec. Mfg. Co.

Theatre:
George H. Porter, Western Electric Co., Chairman; H. C. Meloy, L. S. & M. S. R. R.; A. J. Farrelly, C. & N. W. R. R.; Geo. R. Berger, Gould Coupler Co.

Dinner Dance:
G. H. Atkin, Electric Storage Battery Co., Chairman; G. R. Gilman, C. M. & St. P. R. R.; L. S. Billau, B. & O. R. R.; J. E. Gardner, C. B. & Q. R. R.; Fred Skeel, Crouse-Hinds Co.; B. L. Winchell, Kerite Ins. Wire & Cable Co.; A. J. Cole, Westinghouse Lamp Co.

The Electric Locomotive in Switching Service

All freigh. cars on the New Haven representing about 75% of all the tonnage to and from New England, have been handled by electric switching locomotives. These have proven to be far superior to steam locomotives both as to speed of handling cars and reliability of service. Six electric locomotives replace practically twelve steam locomotives. They are kept in service 24 hours a day.

Of all freight hauled in and out of New England by rail, the New York, New Haven & Hartford R. R. handles 75 per cent of it. The majority of this freight is carried via the Harlem River Division and the Harlem River and Westchester freight and transfer yards.

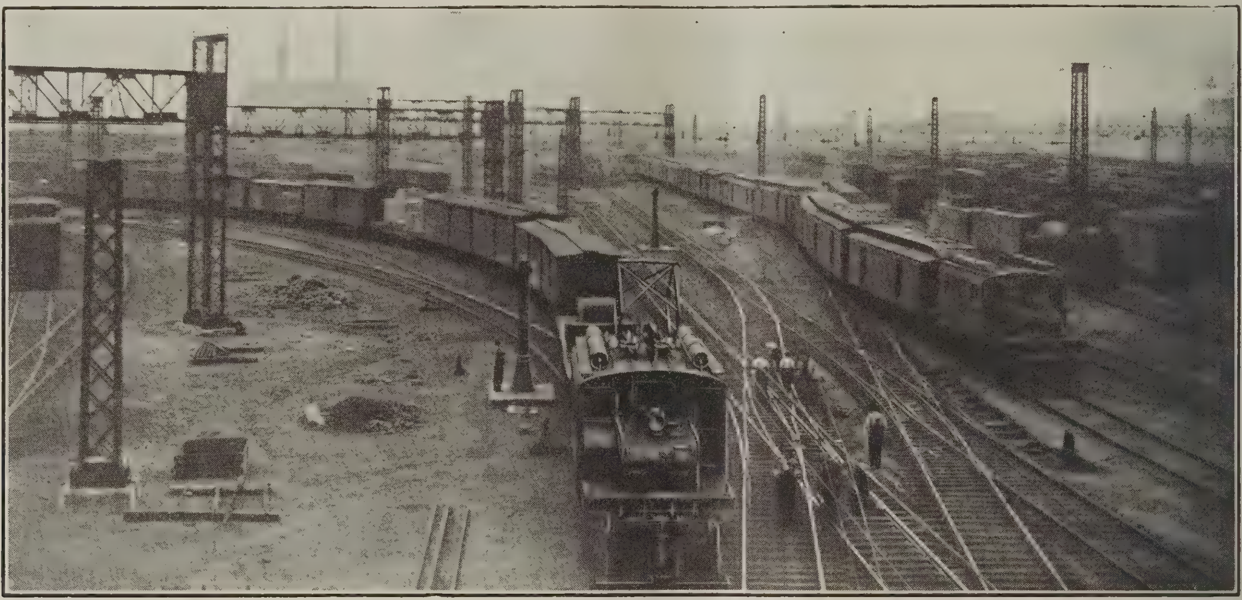


Fig. 1. N. Y. & H. & H. R. R. Electric Switchers in Operation at Oak Park Yard

Although the complete electrification of this road between New York and New Haven has not yet been placed in electrical operation, the switching of all freight cars between Stamford and Harlem River has been done successfully by electricity for approximately 18 months. The economies obtained by the use of the electric switcher locomotives have exceeded all the expectations of those who are responsible for their application to this field.

The reliability of this switcher locomotive equipment has proven to be far superior to the steam locomotive in switching service. The operation of these electric switcher locomotives is a source of satisfaction to the operating department and trainmen who have this work in charge.

Service.

The three main switching yards on the New Haven system are: the Harlem River Yard, 23.3 miles in length, the Oak Point Yard, 37.16 miles long, the Westchester Yard, with a length of 22.29 miles. Also the Van Nest Yards which are used for storage only.

In March 1912, the first switching engine was placed in operation at Stamford, Conn. In August 1912, the first switcher started to work in the Westchester Yards; in September 1912, the first in the Oak Point Yards in float service and in August 1913, the first began its operation in the Harlem River Yards proper.

The Oak Point Yard is the terminal where all the cars on floats destined to New England States are loaded or unloaded.

The floats are docked and secured. A gang bridge on the mainland connects the track on the dock to that on the floats. When either loading or unloading floats, there are always two flat cars coupled between the electric switcher locomotive and the cars being hauled on or off the float. In this way the locomotive always remains on land and is never supported by the approach and the two flat cars act as an arm for reaching the train.

To date not a single feature has developed in which the electric locomotive is not superior to steam locomotive in switching service. The ease with which electric locomotives are controlled, the elimination of stand-by losses and those that are necessary where coal and water are used, elimination of liability for freezing up in cold weather, are all features which are to be credited to the electric locomotive.

Six single-phase electric locomotives do the work of approximately twice the number of steam locomotives formerly used. A total of eight of these electric locomotives is sufficient for practically all of the switching work between Stamford and Harlem River station. These are kept in service 24 hours a day, each making on the average of approximately 140 miles in 24 hours with three eight-hour crew shifts. The electric locomotives handling the work between Westchester Yard and Harlem River for a given month made 38,000 locomotive miles and consumed approximately 896,000 kilowatt-hours of electrical energy at the locomotive.

During the same period, the six locomotives handled approximately 65,000 cars which had a total weight of approximately one million tons. Practically all of these cars were transferred from floats and since the control of the electric locomotive is more sensitive than the control of the steam locomotive, this is a feature that appeals strongly to the operators.

All of the heavy freight tonnage mentioned above is handled within the corporate limits of New York City, and the elimination of smoke by the use of the electric locomotive is another advantage which has appealed to all parties.

There are sixteen switching locomotives included in this installation. Each locomotive is equipped with four Westinghouse 125-h.p., 25-cycle, single-phase motors and Unit Switch Control. These locomotives each weigh 80 tons and are able to exert a maximum tractive effort of 40,000 lbs. with a clean dry rail. Several items given below such as hauling capacity, weights and mechanical data may be of interest.

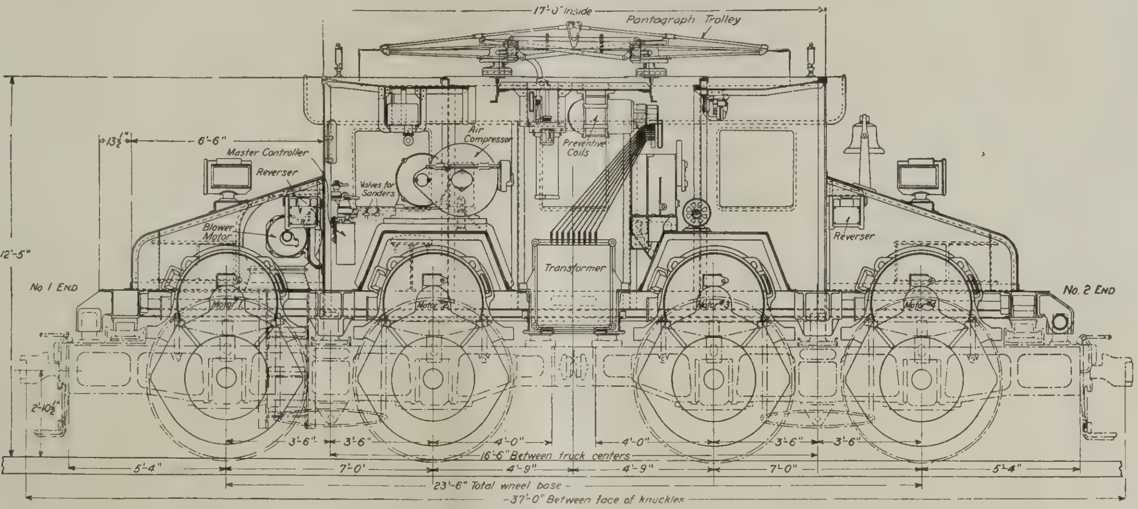


Fig. 2. Cross Section of Switcher Showing Location of Motors and Equipment

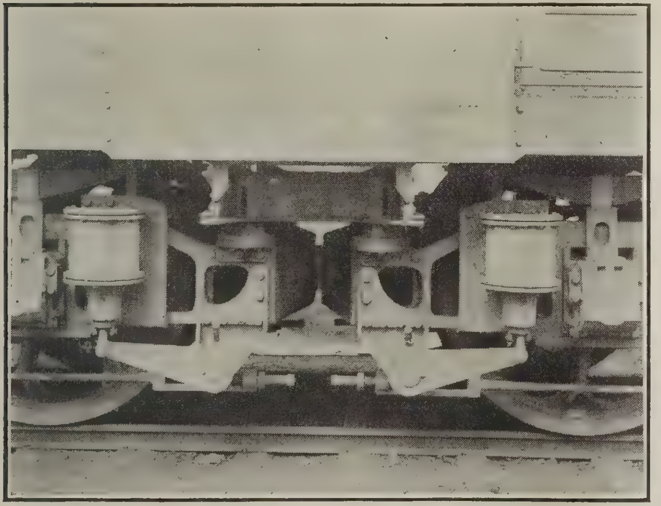


Fig. 3. Showing Connection Between Trucks

Rated Hauling Capacity*

Track Profile	Number of Cars each Weighing 45 Tons with Load	Max. Speed M. P. H.
Straight level track	67	8.5
½% grade	28	8.1
1% grade	17	8.1
2% grade	9	8.1

---

*On the average road, the load that can be handled is determined by the maximum grade.

The figures given for "Straight Level Track" show the load which may be handled in infrequent switching service.

The switching locomotives are guaranteed to exert a maximum tractive effort of 36,000 lbs. for about three minutes at speeds up to 6 m.p.h. and a continuous tractive effort of 14,800 lbs. at a speed of 11½ m. p. h. In practice it has been found that an electric switching locomotive can do the work of two steam locomotives because it can be operated both day and night. In fact, the first switching locomotive furnished has been in use for about 20 hours a day in the yards at Stamford. It is not expected that the maximum voltage on the motors will be reached in ordinary switching service, but it is available when climbing grades or on longer runs in the yard. The average operating potential is estimated to be 190 volts. The hour rating corresponding to this voltage and current of 900 amps., is approximately 125 h.p. per motor.

Arrangements have been made for a large bridge, known as the interconnecting railroad bridge, between Harlem River and Long Island City, which will physically connect the Pennsylvania and New Haven Systems. Electricity as a motive power will be used entirely for handling all traffic over this bridge.

A detail description of these switcher locomotives follows:

Mechanical Features of Electric Switching Locomotives.

The sixteen switching locomotives are of the eight-wheeled 0-4-4-0 articulated truck type with central cab and sloping ends. The pulling and buffing strains are taken by the truck frames, which are joined at the center of the locomotive by a drawbar. The frames are placed outside the wheels, and are steel castings of the usual bar type, having straight pedestal and removable gibs. The semi-elliptic springs are placed directly over the journal boxes, and the springs of each truck are connected by equalizing beams. There is no cross equalization with this arrangement; that is, the equalizer system of one side of the locomotive is not connected with that of the other side.

The end bumpers are of cast steel, arranged for Westinghouse friction draft gear. At their inner ends, the frames are braced transversely by steel castings and these are provided with pockets which carry the intermediate drawbar. These castings also serve to transmit buffing shocks when the locomotive is coupling or pushing.

Each end of the armature shaft is equipped with a pinion which meshes with a steel tired gear. These gears are mounted rigidly in a quill which surrounds the axle with a clearance sufficient to allow vertical wheel play. The quill is carried in journals formed in the motor frame. The motor tractive effort is transmitted from the gears to the wheels through helical springs, rigidly attached at their ends to the wheel center and gear center respectively. With this arrangement, the motors are spring supported, and the center of gravity of the locomotive is at a suitable height above the rail.

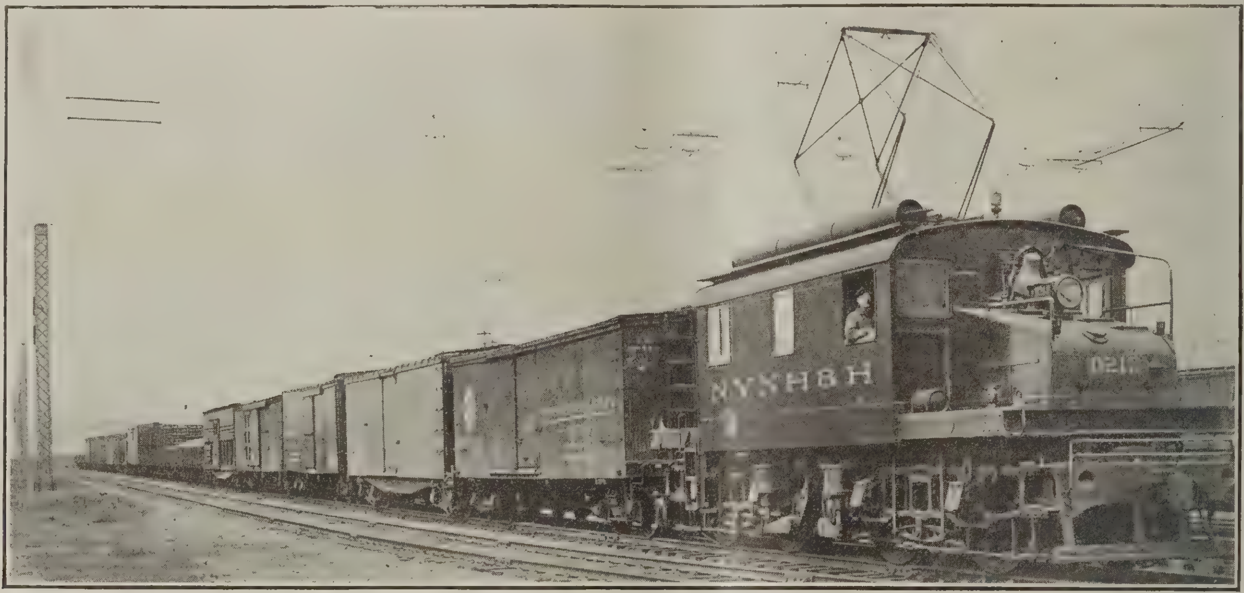


Fig. 4. 80-Ton Baldwin Switcher at Work. Note the Overhead Trolley Construction, Permitting of any Desired Number of Switches, Crossings, etc.

As these locomotives operate on the New Haven tracks only, no provision has been made for collecting current from a third rail. The locomotives have been designed to traverse 20 degree curves.

Motors and Blowers.

The railway motor is of the series type with short-circuited compensating windings and preventative resistance leads to the armature circuit. The motor is designed with eight poles. The main field winding consists of concentrated field coils, each of which has a few turns of heavy copper strap, and is in its general construction very similar to the field coils used in large D. C. railway motors. The auxiliary or compensating winding is distributed in the slots provded in the pole pieces. It consists of heavy copper bars, one in each slot, and straps interconnecting these bars at the ends.

The armature winding consists of heavy copper strap, and the resistance leads in the armature are made of strap of high resistance materials. It will be noted that windings are made of bars or straps and are, therefore, of a very strong and reliable structure, a feature which is exceedingly desirable for railway work. This combined with the fact that the compensating windings are practically eliminated, and the fact that the voltage of the motor is very low, far below the customary voltages on d. c. railway motors, makes this motor as reliable a structure as can be imagined at the present state of the art.

The motors are connected in two pairs, so arranged that the two motors of each pair are permanently in series, while the two pairs are permanently in parallel. The speed regulation is obtained by connecting the motors to different taps on the secondary winding of the transformer in the same way as is done on all the previous New Haven locomotives.

These locomotives are controlled by means of a master controller located in each side of the cab. A sixteenth locomotive has been built in which a single controller in the center of the cab is provided for operation in either direction.

An ammeter is provided near each master controller to enable the engineer to know just what load each pair of motors is taking at any time, so that he can handle the locomotive to the best advantage. In the case of a switching locomotive it is especially desirable to know when it is capable of hauling extra heavy loads; in other words, to know the temperature condition of the motors. For this reason, there has been installed a temperature indicator which is built on the principle of the wheatstone bridge. The connection of this instrument is made through a coil in the motor fields.

A novel feature in the main circuit connections is that the motors are operated from a two coil transformer instead of an auto-transformer, thereby reducing the insulation strain on the windings to a minimum.

A number of interesting features regarding these locomotives are given below:

Weights

Per driver axle	39,780 lbs.
Mechanical parts	83,390 lbs.
Transformer	6,000 lbs.
Motor complete with gear and gear case and quill drive	13,585 lbs.
Control equipment and details	10,675 lbs.
Forced ventilating equipment	770 lbs.
Air-brake equipment	3,950 lbs.
Total weight	159,120 lbs.

Mechanical Data

Type of trucks	4 wheels, articulated and swiveled
Truck wheel base, rigid	7 ft. 0 in.
Total wheel base	23 ft. 6 in.
Length between coupler knuckles	37 ft. 0 in.
Type of cab	steeple
Length of cab inside	17 ft. 0 in.
Length of hoods	6 ft. 6 in.
Width of hoods	5 ft. 0 in.
Width over all	10 ft. 3 in.
Diameter driving wheel	63 in.
Total height over cab roof	12 ft. 6 in.
GGauge	4 ft. 8½ in.

The Development of the Gas Filled Mazda

C. L. Dows*

Author shows extremely low efficiency of conversion from power in coal or water to light. The development of gas filled mazda increases this efficiency twice over. Heavy filament is coiled into fine spiral. Bulb is filled with inert gas at atmospheric pressure, this makes it possible to greatly increase the temperature of filament. Lamps are at present made only in large sizes, except for series circuits. Light is much whiter than with carbon or vacuum mazda.

Since the announcement of the new high efficiency mazda lamp, many improvements have been made and progress has been rapid. Developments have followed in quick succession, one after another. New fields have been developed, the old fields have been extended, new lamp processes have been put into practice, and the industry as a whole has been lifted to a higher plane. The new lamp has been looked upon by some as an ordinary lamp filled with nitrogen or containing some other inert gas within the bulb and there are few except those intimately connected with its development who realize the difficult problems which have had to be met and solved. It is not unreasonable to expect still further developments, for the lamp is yet in its infancy.

The new lamps have not been brought about by any sudden development; they are rather a result of gradual evolution in the art of incandescent lamp manufacture. The improvements which have been going on since incandescent lamps were first placed on the market about 1880 have all contributed to the latest achievement.

The carbon lamp of 1880 burned at an efficiency of about 7 watts per candle, corresponding to 1.5 lumens per watt. About 1896, carbon lamps had apparently reached the limit of their efficiency, 3.1 watts per candle, or 3.5 lumens per watt. The development of the Gem lamp increased the efficiency to slightly over 4 lumens per watt, the tantalum lamp raised this figure to about 5, and the pressed tungsten filament to about 8 lumens per watt. The pressed filament gradually evolved into the strong, durable drawn wire tungsten filament of today and the efficiency was increased to 1 watt per candle, corresponding to 10 lumens per watt.

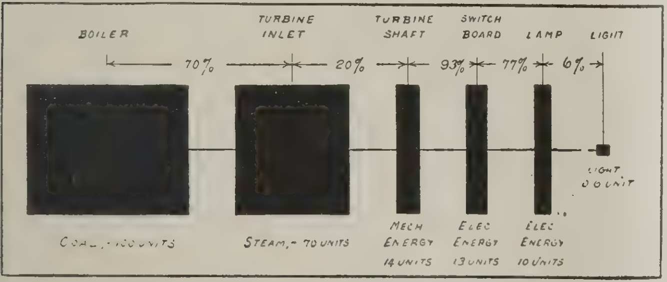


Fig. 1. Efficiency of Conversion from Coal to Light with Boiler and Steam Turbine

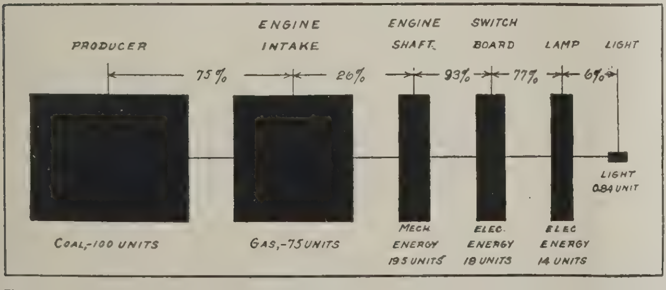


Fig. 2. Overall Efficiency from Coal to Light with Producer Gas Engine.

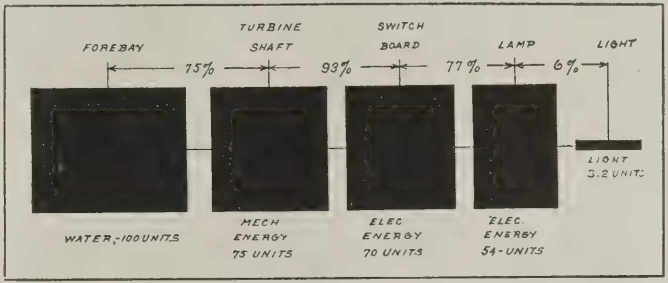


Fig. 3. Efficiency of the Hydroelectric System in Producing Light

It is interesting to note in this connection, the overall efficiency of light production with the Mazda lamp of the vacuum type operating at 1 watt per candle. Fig. 1 shows graphically the efficiency conversion from coal to light in a steam turbine electric system. It will be noted that the over-all efficiency from the coal pile to light is but 0.6 of 1 per cent. The over-all efficiency for a producer gas engine electric system, Fig. 2, is 0.84 of 1 per cent, and for the hydroelectric system, Fig. 3, which is the most efficient of the three, the over-all efficiency becomes 3.2 per cent.

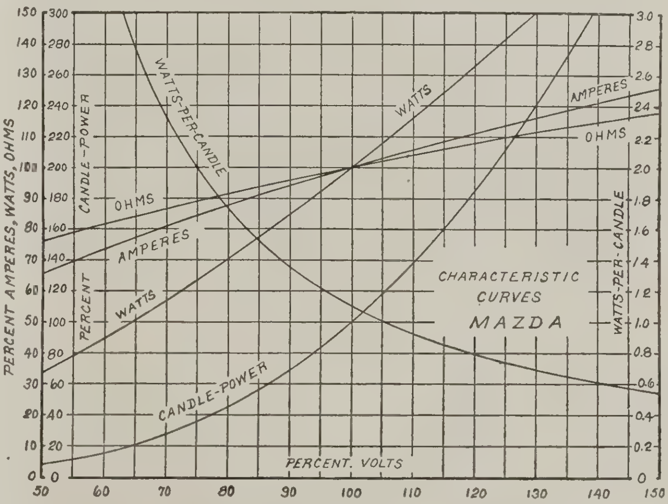


Fig. 4. Characteristic Curves of Mazda Lamps

It is evident from a consideration of the above figures that light is at present produced very inefficiently and there is opportunity for revolutionary developments.

In Fig. 4 are shown the characteristic curves which apply in general to either type of mazda lamp. Although they are shown on the basis of 1.10 watts per candle, which at present is the normal efficiency of the 40-watt, 105-125-volt lamp, it will be seen that if a lamp of the vacuum type is burned at a voltage 50 per cent higher than its rated voltage the efficiency will be increased to about 0.55 watts per candle, which is the efficiency at which the present 1,000-watt gas-filled mazda lamp operates. However, the bulb of a vacuum lamp burning at this voltage would blacken very rapidly and the lamp would live but a few hours. While it is therefore possible to operate any mazda lamp at an extremely high efficiency, it is by no means practical to do so. The new 1,000-mazda lamp operates at 0.55 watts per candle, the bulb is not appreciably blackened, and the life of the lamp is fully equal to its rating.

---

*Engineering Department National Lamp Works of General Electric Co.

For some time experimental work has been done towards introducing an inert gas within the bulb of an ordinary lamp. These experiments met with failure because the conduction and convection losses permitted by the gas were so great that it was necessary to send a prohibitive current through the filament to cause it to burn. With the development of the coiled filament, however, with its heat retaining properties, the gas-filled lamp met with immediate success. Fig. 5 is a reproduction of a photograph of the filament of a 250-candlepower gas-filled, street series lamp, showing the manner in which the filament is coiled. Drawn tungsten wire is wound on a fine mandrel which is later removed, leaving the filament in the form of a closely coiled spring. This filament is then wound on the supporting hooks in much the same manner as a straight filament is wound.

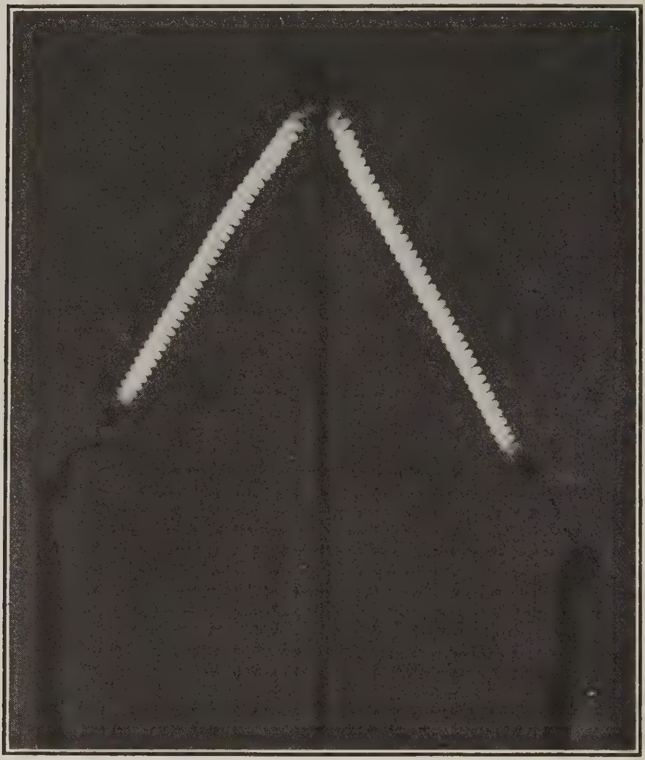


Fig. 5. Enlarged Photograph of Filament of 250 Candle-power Gas Filled Mazda

The life of an incandescent lamp is determined by either one of two factors: first, the filament may fail; second, the disintegration of the filament caused by the high temperature at which it operates results in a deposit on the bulb which cuts down the candle-power. Since a lamp is considered as having reached the end of its life when the candle-power has decreased to 80 per cent of the initial candle-power, it is seen that, although a lamp may still be burning dimly if the candle-power has dropped to 80 per cent of initial, as far as the lamp manufacturer is concerned, the lamp has failed. The purpose of the gas within the bulb is to retard the evaporation of the filament and consequently lengthen the life of the filament and reduce the bulb deposit. It is a matter of common knowledge that the evaporation of water is contingent upon the pressure upon the surface of the water—for example, water boils at 100 degrees Centigrade under atmospheric pressure, but if the pressure is increased, the boiling point of the water is increased above 100 degrees. This illustrates the principle underlying the use of the inert gas.

As has been stated, the coiling of the filament reduces the conduction and convection losses; furthermore, it has been found by experiments that these losses are relatively less for filaments of a large diameter than for filaments of a small diameter, the reasons for which will not be gone into in detail here. It is evident, then, that a balance must be effected between the advantages gained by reduced evaporation and the disadvantages occasioned through conduction and convection losses. At the present time, the smallest lamp for regular multiple lighting service is the 400-watt lamp. Below this wattage the disadvantages of the new losses more than offset the advantages of retarded evaporation. The upper limit has not as yet been determined, but it seems that for all practical purposes the 1,000-watt lamp, which gives over 2,000 candle-power, is as large a unit as there will be a demand for. However, units giving over 10,000 candle-power have been made for experimental purposes.

Not only is the greatly increased efficiency of the new lamps an important advantage, but the improved color quality of the light is also distinctly in their favor. In Table 1 are given the comparative color values of various types of incandescent lamps at their respective operating efficiencies. While the light of the new lamps is far from the true daylight value, it is apparent that a marked advance has been made. It is possible, by the use of color screens, to obtain daylight color values from the new lamps at an efficiency corresponding approximately to the efficiency of the bare mazda lamp of the vacuum type.

Among the fields which have been opened to the incandescent lamp through these latest developments may be mentioned flood lighting of building exteriors, the artificial lighting of studios, and the stereopticon lantern field. Two concentrated-filament lamps for this purpose have already been developed, the 250-watt and the 500-watt. The trouble which has always attended the operation of an arc lamp stereopticon is entirely eliminated. The lamps burn on either alternating or direct current and throw a strong, steady, clear light at the snap of the switch.

In conclusion, it will be well to say that future developments may be reasonably expected. It is probable that before long lamps of smaller size than 400 watts embodying the new construction will appear upon the market, but no definite statements can be made at this time. The incandescent lamp industry is in the midst of a period of rapid development. It is only with the constant co-operation of those whose work demands an efficient light, a high candlepower unit, or a concentrated light source that the advantages possessed by the new lamp may be fully realized.

TABLE NO. 1

COMPARATIVE COLOR VALUES OF VARIOUS TYPES OF INCANDESCENT LAMPS AT THEIR RESPECTIVE OPERATING EFFICIENCIES.

	Values at 100% Normal Volts		
Type of Lamp	% Red	% Green	% Blue
Untreated Carbon	100	44	7
Treated Carbon	100	45	7
Gem	100	48	8
Tantalum	100	50	9
Mazda (Vacuum Type)	100	52	13
Mazda (New Type)	100	66	21

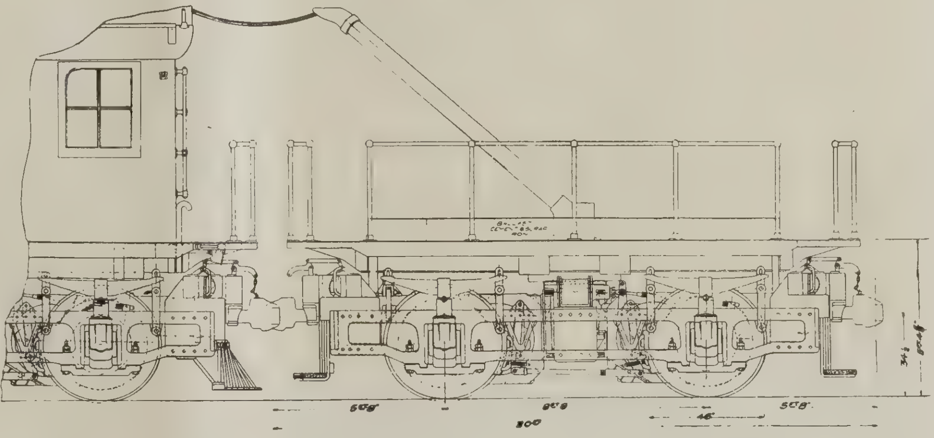
Auxiliary Trucks for 2400-Volt Locomotives

Abstract.

Standard 2,400-volt locomotives are equipped with four motors, two connected permanently in series. On starting, all four motors are operated in series with grid resistance in circuit. Where the locomotives are to be operated continuously in slow speed switching service, etc., an additional truck is added, carrying two motors which are operated in series with the four on the standard locomotive, thereby utilizing the energy which ordinarily is wasted in resistance units. This increases the capacity of the locomotive by 50 per cent; the high speed of the combination is the same as the regular locomotive since all pairs of locomotives will operate in parallel and low speed efficiency is very much higher than standard locomotive.

The 2,400 volt electrifications of the Butte, Anaconda & Pacific Railway was described in the *Railway Electrical Engineer* for March, 1914. Another interesting development in connection with this electrification is the application of auxiliary trucks for switching and slow speed freight locomotives. These trucks, as shown in the accompanying illustration, are an ingenious adaptation of standard parts of the freight locomotives. It will be recalled that in the standard locomotive there are 4 motors mounted on each locomotive and 2 of the motors are permanently connected in series. In starting all 4 are connected in series. Suitable resistance steps, of course, must be provided, and in starting and in very slow speed work the locomotives operate at lower efficiency.

With the addition of this auxiliary truck, however, 6 motors are placed in series on starting and on slow speed, so that instead of dissipating energy in resistance boxes, it is made use of in the armatures of the auxiliary motors. The standard locomotive is an 80 ton unit. This, with the addition of auxiliary truck, which is ballasted up to 40 tons, makes a total of 120 tons for the compound unit. These units will be used specially for the spotting cars at the smelter and also for slow speed switching in the Butte yards.



Tractor Truck for 2400-Volt Locomotives on a Heavy Grade and Slow Speed Service.

While the new locomotives are adapted especially to switching service, they are also capable of operating in combination with any of the electric freight locomotives now in service, and have the same electrical and mechanical equipment.

During the present year it is expected that approximately 25 per cent more ore will be transported from Butte to Anaconda than was hauled last year. This increase arises from the transfer of ore which was previously hauled to smelters at Great Falls. The additional haulage will bring the total aunual traffic on the road up to about 6,250,000 tons.

The three two-axle tractor trucks, referred to above, will each be equipped with two GE-229 motors, insulated for 2,400 volts, similar to those on the locomotive. Cable and connecting plugs will also be provided for operation with the locomotives, so that the truck motors will be operated with the other motors from the same controller without change in the main control. The number of stops in the control will therefore be the same as on the locomotive; ten points with six motors in series and seven with two sets in multiple, each set consisting of three motors arranged in series. In operation, each of the tractor truck motors is connected in series with one pair of motors on the locomotive, making a six-axle, six-motor unit which will furnish 50 per cent more tractive effort than the 80-ton locomotive alone, at about two-thirds speed, without increase in current output. The characteristics of the 120-ton unit are as follows:

Total weight on drivers	240,000 lbs.
Starting tractive effort at 30 per cent coefficient	72,000 lbs.
Tractive effort at one hour rating of motors	43,200 lbs.
Speed at one hour rating, motors in series	4.8 m. p. hr.
Speed at one hour rating, motors in series parallel	10.3 m. p. hr.

Mechanically these trucks are similar in construction to the trucks on the 80-ton locomotives. Instead of a locomotive body, however, a platform is supplied, built up of channels, angles and plates which are supported on the truck transom. Struts are provided at the corners to secure the platform to the side frame. Ballast, consisting of cement and iron punchings of sufficient quantity to bring up the weight of the truck to 40 tons, is placed between the center channels of the platform in a box-like structure built for this purpose. A passageway protected by a hand rail extends along each side of the platform.

In the center of the platform there is a crane which extends at an angle from the platform floor, sutiable for supporting the eight cables necessary for connecting the motors of the tractor to those on the locomotive. This crane can be revolved 180 degrees so as to permit the coupling of the locomotive to either end of the track. When in operation, this crane is rigidly locked in position. Air brake equipment with the necessary triple valve, auxiliary reservoir, etc., is also installed on the truck.

Each of the four locomotives now under construction is provided with a junction box placed near the roof above the front window. This is designed so as to permit the removal of couplers with a small amount of labor and time, so that the tractor may be connected to any one of the freight locomotives which is provided with this junction box.

Electric Arc Welding

In Steam Railway Shops

George W. Cravens

Electric arc welding is coming into very general use in railroad shops, as it is found more economical and convenient for most work than any other method of welding. Very thin welds of sheet steel, as well as heavy welds, can be made. Material can be cut away or built up with equal facility.

The art of cutting, welding and melting metals by the heat of the electric arc is one of the oldest applications of electric power, and yet is the most recently developed one for commercial purposes. The earliest recorded effort to use the arc was made in 1786 by Martinus van Marum, of Leipzig, who used the current from a large battery to melt some pieces of metals. Sir Humphrey Davy did further experimenting in 1810 and one J. G. Children welded iron wires in 1815 with a battery current. Since then the heat of the arc has been used at various times for cutting and melting the various metals, and in 1887 Benardos and Olszewski developed a practical method for using the arc commercially. They used an electrode of carbon and drew the arc between the work and the carbon, using the arc the same as a gas flame. In 1891 Slavianoff further improved the process by using a piece of the filling metal as the electrode and melting it directly into place with the arc.

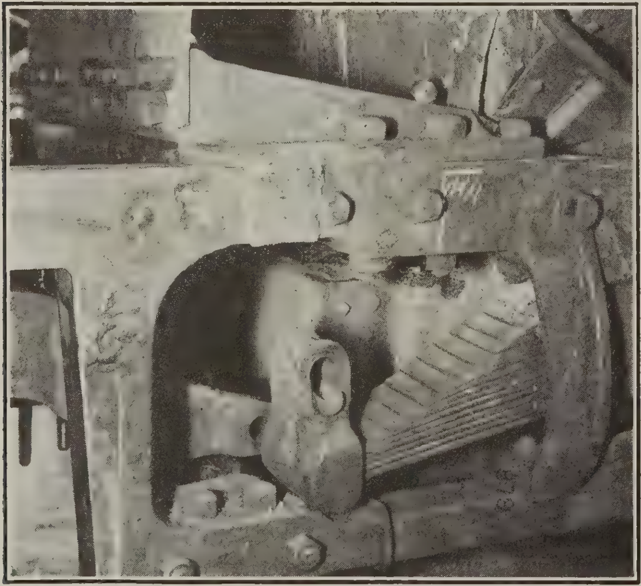


Fig. 1. Engine Frame Showing Weld

In spite of the large amount of work that has been done experimentally while studying the characteristics of the electric arc, comparatively little exact knowledge is available concerning it. The exact temperature of the vapors in an arc has never been determined, but since the heat is sufficient to melt the most refractory substances it is estimated to be about 4,000 degrees Centigrade (7,232 Fahrenheit). About 75 years ago Grove discovered that an electric current would flow more easily from a metal to a piece of carbon than it would the other way, and that the current passing through the arc was greater when passing from an easily oxidized metal to one which was not than when flowing in the reversed direction. This is because the conductivity of the arc depends upon the kind of vapors in it, and since the temperature is higher at the positive electrode of an arc than at the negative it vaporizes the metal better at that end and carries particles of the vaporized metal into the arc.

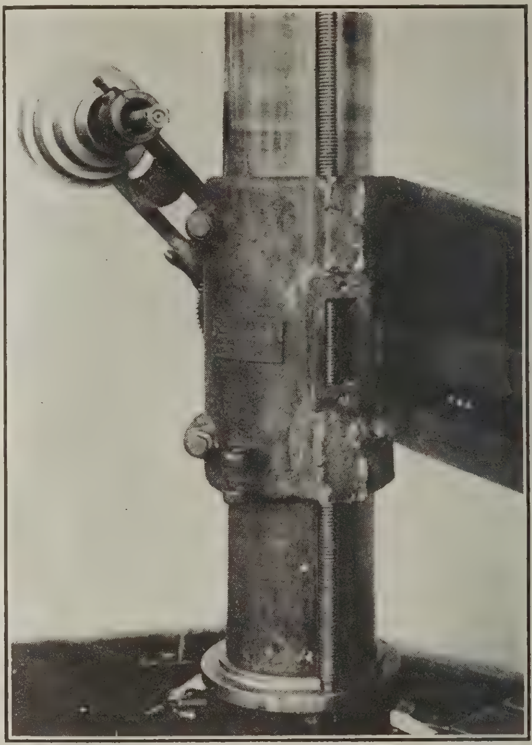


Fig. 2. Drill Press Repaired by Arc Welding

Welding or cutting may be done with an arc from any source of supply, if means are provided for regulating the amount of current flowing, but experience shows that it is necessary to introduce certain refinements into the controlling system in order to insure the best results. It is in the type of controlling apparatus supplied that most of the differences lie between the various outfits on the market today. In order to do welding or cutting with an arc the positive wire should be connected to the work and the negative to the electrode holder, contact made between the work and the electrode, the electrode withdrawn to establish the arc and then moved along over the spot to be welded or cut. The arc will follow the electrode about over the surface of the job and do its work wherever it strikes. If the current traveled from the electrode to the work the arc would be more erratic because it would tend to jump across the shortest path, but coming to the point of the electrode it is bound to hit at the small end and thus be easier to control and steadier. The same thing applies to work done with a metallic electrode as when a carbon is used.

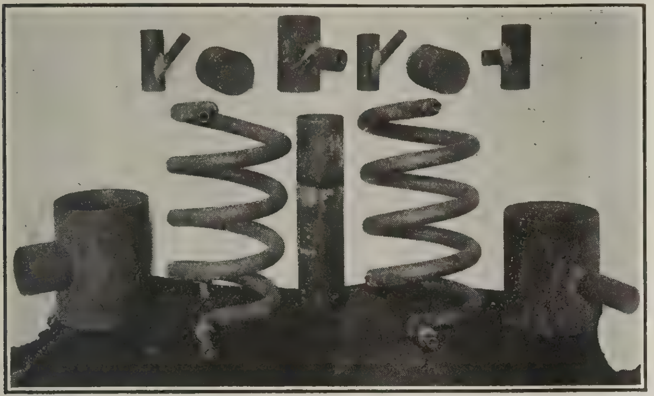


Fig. 3. Thin Metal Pieces Welded with Metallic Electrodes

So many of the railroads have arc welding apparatus installed that the general principles of the apparatus are well known, but for the benefit of those who do not know it may be said that there are two general methods in use. One of them is known as the Bernardos process and consists in drawing the arc between the job and a carbon stick and using the arc the same as a gas flame for fusing a melt-bar into place, or as a flame to melt out the metal when cutting. The other is known as the Slavianoff process and consists in drawing the arc between the job and a piece of the filling material, thus enabling the operator to deposit his metal as he goes along. The latter process is the one used for boiler repairs and is most always used more than the carbon arc process for railway shop work. Direct current at about 70 volts is used, and a compound-wound generator is the best scource of supply, although those outfits with the most complete controlling attachments for the welding circuits do the best work. Several companies make welding apparatus now and they will be described later.

The metallic electrode is used for all classes of sheet and plate welding and for repairs of moderate size on castings and forgings. It is also used for some large jobs such as welding broken locomotive side frames and filling up parts of steel castings. Sheet steel as thin as 28 gauge has been successfully welded with metallic electrodes by one of the manufacturers and articles of 20 gauge are in regular production. The graphite electrode is used for cutting, pre-heating, welding iron and steel castings and various jobs requiring large amounts of heat. This is the method used for welding copper and aluminum and their alloys as well as the steel alloys such as manganese steel, etc. Brass is hard to weld successfully because the zinc volatilizes so easily at high temperatures but bronzes with high percentages of copper can be welded if zinc is not present in appreciable amounts. Broadly speaking, the metallic process is limited to iron and steel whereas the graphite electrode may be used for any metal, the only limitation being that the work must be in a horizontal position to prevent the molten metal from running off because the process consists in puddling the filling material into place. When cutting it is necessary to give the metal a chance to flow off.

There are six welding outfits on the market in this country today, five of them using low voltage generators as the source of current, and the other using a set of iron grid resistance for cutting down the line voltage to that required for working. The latter is very wasteful of energy, of course, because most of the energy used is wasted in the form of heat through the resistance, but several of them have been installed because of the low first cost. Barrels of water with two plates in them are about as good and much cheaper, but good work demands the use of a low-voltage generator as the main feature of the apparatus. There are two companies offering outfits consisting of compound-wound generators with driving motors, and non-automatic control for the welding circuits, and one offering a single unit machine with similar control. Another company uses a shunt-wound generator operating on full load at all times, merely throwing the load from the arc to a resistance when not welding. This system is almost as inefficient as a water barrel, although several of the outfits are in use in railroad shops. The other company also uses a compound-wound motor-generator set but supplies automatic controlling devices for each of the welding circuits and is able to do much better work as a result. It is obvious that the best work demands the best apparatus, and that the means for controlling the arc are the most important features of any outfit. Pro-

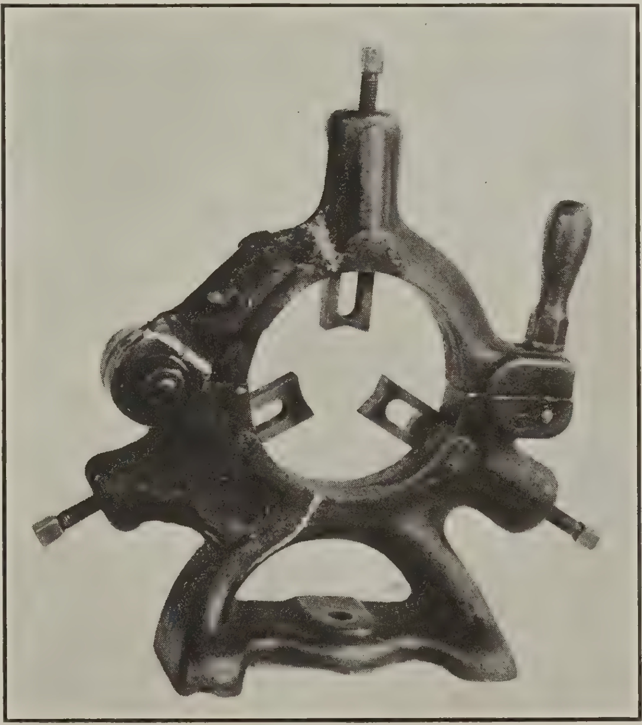


Fig. 4. Lathe Steady Rest Repaired

vision must be made to prevent burning the work as well as to protect the machine, and the more nearly automatic and complete this is the better it will be.

During the past year great strides have been made in the application of electric arc welding to locomotive repairs and there are today about 2,000 engines running with repairs of some kind on them. Most of them have had leaky seams repaired and a large part of them have their flues welded in. The most accepted method of welding in the flues is to omit the copper ferrule, expand and bead the flue in the usual manner, prossering also if desired although it is not necessary, and then welding around the edge of the bead in order to tie it to the flue sheet. The life of such a joint will be greater than the three years allowed for the flues and when properly done it will never leak. Current required is about 120 amperes and a wire one-eighth of an inch in diameter should be used. For cracks and corroded seams in the sheets a five-thirty-seconds wire and about 160 to 165 amperes used, and for overhead work the same wire and from 180 to 185 amperes used. For iron castings the graphite electrode and about 165 amperes are required, but such articles should be pre-heated before welding to prevent cracking when cooling on account of shrinkage. Broken wheel centers, journal boxes, cylinders and other castings of iron or steel are being saved daily by this process in addition to the large amount of work on boilers and an occasional side frame. Repairs to cars and trucks and many broken machine tool parts in the shops are also being made by arc welding, thus avoiding delays and expense when getting new parts.

The best arrangement for use in steam railroad shops is to mount the motor-generator set in some central position, such as in a gallery in the erecting shop, and have its control panel either near the machine or on the main floor just below it. From the control panel the distribution circuit should be run through the shop and the welding control panels tapped into it just the same as so many motors. These welding panels may be located wherever most convenient and the welding wires run from them to the work without having long leads lying about the floors. Welding panels are sometimes made portable and carried wherever needed temporarily, and may be equipped for either graphite or metallic welding, or even with both. Lines are sometimes run from the control panel to other shops and round houses so work may be done on locomotives wherever they stand, and some of the larger railroads have small welding machines in division shops and round houses along their lines to take care of troubles as soon as they develop, thus realizing enormous savings every year. It does not take long to pay for a welding outfit from the sum saved by not doing the work in the old ways.

The cost of welding with the electric arc, using current from a good compound-wound, low-voltage generator and a suitable control system for the welding circuits, averages about one-third that for the same work with oxy-acetylene apparatus and about one-sixth that for other processes. On this basis there is really no reason why every shop and round house in the world should not have an arc welding outfit as a part of its equipment, and the day is coming when such apparatus will be considered as indispensable as a drill press or an air tool.

Cost of Arc Welding Repairs.

As an illustration of the great economies to be realized through the use of electric arc welding apparatus, instead of the other methods of repairing locomotives and cars, the following examples will give the actual figures prepared by some of the roads using this apparatus.

	Old	New
Fire box cracked, mud ring broken, flue sheet leaked, all repairs made by old and new methods.........	$ 174.60	$ 73.90
Mud ring broken at corner, removed and welded by smith, also one electrically welded in place	124.66	21.15
Cracked side sheet, patch rivet on *versus* welding	15.54	8.75
Flue sheet badly worn by frequent repairs, replaced and riveted, against building up electrically....	163.63	55.75
Engine frames, both broken, removing and smith-welding against electric weld in place...............	56.20	11.80
General repairs on fire box side sheets, replacement *versur* electrically welding in place..........	342.62	66.51
Cylinder badly cracked, replacing or welding	367.15	22.35
Broken mud ring, removing and replacing or welding	118.06	32.07
	$1,362.33	$292.28

Total saving on the eight jobs described......$1,069.45

These eight jobs could all have been done within one week by two men of ordinary ability, with apparatus equipped with suitable control devices, and the money saved would go a long way towards paying for the outfit. The great saving due to being able to work without dismantling is one of the most important features of this system, and this enables the rolling stock and motive power to be returned to service very quickly.

In car shops this system is being used for most of the joints in both exterior and interior finish, as well as for some parts of the frame. Electric welding is especially useful when making repairs, because extra pieces can be welded to the old parts without removing them, and when it is necessary to cut away any pieces it can be done by using the graphite electrode, drawing the arc and using it the same as a gas flame. For the truck frames, journal boxes and other castings, this system is very valuable for reclaiming by welding cracks, building up worn or missing parts, and similar operations.

Electric Welding While You Wait.

A workman in a railway shop approached his foreman not long ago with a request for a new machinist's hammer, showing his former tool split into longitudinal halves as the result of a heavy blow. Being busy, the foreman in a half-joking manner said, "Take it to the electric welder; we're out of hammers." Without question the workman obeyed. Later the foreman noticed the man lustily chipping a nut and asked him where he got the new hammer. The inquiry elicited the fact that two pieces of the broken hammer, small and irregular as they were, had been welded electrically with neatness almost defying detection. Whether this was an economical process has yet to be determined, but as evidence of the electric welder's general usefulness the incident is worth chronicling.—*Electric World.*

The Edison Storage Battery

H. H. Smith

Paper Before R. R. Elec. Club, Chicago

The conditions of train lighting service are among the most favorable to which a storage battery can be subjected. The rates of charge and discharge are predetermined and fixed by the use of various forms of regulators and controllers, and the batteries are usually cared for under a carefully systematized plan. All of this tends to make possible a routine comprising the conditions recommended by the battery manufacturers as productive of the most favorable results.

The very largeness of this branch of the industry and the nature of the service make necessary the carefully arranged routine and the accurate control is made possible by the very ingenious devices that go to make up the auxiliary equipment of the electrically lighted car.

The service requires of the battery that it be reliable—always ready when called upon to do its work, constant in its characteristics and requiring the minimum of special treatment in order that it may readily adapt itself to the routine necessary in this work. Given, therefore, a battery that is adaptable to routine we find that the service which imposes the most nearly ideal conditions for that battery is that which *is* routine.

Economy is also a matter of supreme importance and is one that is given perhaps more earnest and detailed consideration by the railroads than by any other class of battery users.

You have invited me here this evening to tell you something of the relations between the alkaline storage battery and the art of train lighting, and I rather anticipate that after I will have finished you will have ready a number of questions to put to me covering points that I have failed to consider.

Early Developments.

At the present time there is but one alkaline storage battery on the market. It is one of the many products of the genius of Edison. (Edison, by the way, was once asked for his definition of genius and he replied "It is inspiration 1%, perspiration 99%.")

At about the time that train-lighting by electricity began to be a reality, namely at the beginning of the present century, Edison began experimenting with the storage battery; not having in mind, however, as far as we know, its use for train lighting. He was aiming rather to displace the horse as motive power for street vehicles. In 1904 the first Edison battery was placed on the market, but was soon withdrawn, because a better design had been conceived. In this early battery both the plates were flat like the present negatives, but it was found that this construction was not mechanically strong enough for the positive plate.

After the withdrawal of what was known as the "E" type battery, the work of developing the new positive was carried on day and night for four years, and late in 1908 the present A type was placed before the public. In 1909 the "B" type followed. This is merely a modification in the size of plate—in all other respects it is the same as type "A."

By this time electric car lighting was a fairly well established art and early in 1909 a few sets of Edison battery were purchased for experimental purposes. These worked out so well in all respects with the exception that it was found inconvenient to flush as frequently with water as was the practice in other classes of service, that in 1911 a special cell was developed for car lighting. It differed from the regular A type only in having a higher can which permitted of a depth of solution about 3 inches above the tops of the plates.

Battery Construction.

The structural features of the battery are so distinctly different from those of other storage batteries, and therefore so readily impress themselves on the memory, that it is probably hardly necessary, here, to describe them. A brief review, however, of the salient features may serve to inform some and refresh the memory of others.

Externally the cell appears as a sealed metallic container with corrugated sides. Through the top the tapered poles project and between them there is a single opening which permits of filling with water or solution as required. The hinged cover to this opening carries a loosely hung spherical hard-rubber segment which seats against the mouth of the vent and prevents ingress of air or other foreign matter. At the same time it permits the cell gases to escape and acts as a separator for the moisture held in suspension by the escaping gases. The poles pass through stuffing boxes which prevent the passage of gas or liquid. The body of the cell is coated with a black insulating and protecting compound.

The active elements of the cell are nickel and iron and the electrolyte is potassium hydrate in solution with a small quantity of lithium hydrate.

The positive plate consists of spiral tubes made from perforated, nickel-plated, steel ribbon. These are filled with alternate layers of green nickel hydrate and metallic nickel flake—about 300 layers of each. Each tube is strengthened by eight seamless steel rings which circumscribe it equidistantly along its length. Both ends of the tubes are flattened, forming terminals for clamping, under heavy hydraulic pressure, into the nickel-plated steel grid.

The negative plate consists of flat pockets, likewise of perforated steel, nickel-plated, which are filled with finely powdered metallic iron. The nickeled steel grid is punched to receive the filled pockets and then the whole is subjected to a pressure of many tons. This pressing operation compacts the active material, corrugates the pocket surfaces and squeezes their edges into intimate contact with the grid.

Each group is then mounted on a horizontal rod attached perpendicularly to the lower end of one of the poles and the plates are fastened in place by steel nuts and washers.

Various sizes of A and B type cells are made containing different numbers of plates.

For train lighting the A8-H cell is in most general use. The letter A designates the size of plates, the numeral indicates the number of positive plates, the negative being always one in excess, and the letter H signifies the high can previously mentioned as having been especially designed for this service.

The finished cells are mounted three each in trays conforming to the standard dimensions long ago established for train lighting batteries. This necessitates the batteries being assembled with unnecessarily large spacing between the cells. One railroad has found it profitable to depart from the standard practice and take advantage of this extra space by using smaller compartments, thus reducing the weight and cost.

The weight of a standard tray of three A8-H cells is in the neighborhood of 100 pounds, which may be readily handled by one man. The battery for 30-volt equipments consists of 8 trays of 3 cells each and one similar tray containing only one cell.

Effect of Temperature on Battery Operation.

The alkaline battery has been the subject of much persistent criticism because of its alleged susceptibility to temperature variations. I know that a number of the gentlemen present have satisfactorily disposed of this criticism out of their own experience and it is useless to mention the matter to them. There are, however, some doubtless who still have the "alkaline battery" and "temperature effect" crowded into the same compartment of memory's storehouse so that every time one is brought forth the other comes also.

Strangely enough, little is said about high temperatures and yet it is high temperature that is really the more serious, because it may effect permanent injury. High temperature will naturally cause the electrolyte to evaporate more rapidly than normally, especially if the high temperature is caused by high charging rates. If the solution then gets below the plate tops the heating effect is aggravated through increased current density at the surfaces immersed and so, unless conditions are carefully watched when undue heating commences, it may rapidly get so far as to cause permanent injury. For short infrequent periods the Edison battery will withstand severe heating better than other types, and it is for this reason that numerous batteries have come through destructive fires with no harm done except to the rubber parts, which may be replaced at small expense. And also why the battery survives sustained short circuits without harmful effect. In train-lighting, injurious temperatures are seldom met with, for the rates are almost never very high and ventilation is usually sufficiently provided in warm weather. On southern roads it has been observed that where conditions are kept right the battery is seldom more than 5 degrees warmer than the surrounding air.

And, again, we must discuss conditions when it comes to a consideration of low temperatures. In the laboratory it can unquestionably be shown that the alkaline battery is somewhat more susceptible to the effect of cold than are others—they are *all* affected, you know. This is partly because of inherent characteristics, partly because of the metallic containers and partly because of the greater cell spacing. In service it has been shown beyond all question of doubt that cold can absolutely be nullified by simple, inexpensive modifications of compartment design. The battery is self-warming—still air is a good heat insulator—a battery surrounded by still air keeps sufficiently warm for satisfactory operation. In a test made a year or two ago, a train lighting battery was housed in a tight metal compartment (except for barely necessary ventilation to permit gases to escape), but with wind space all around the compartment itself. The test was made over a period of 6 weeks of the most severe cold weather. During this period there was a stretch of eleven days during which the temperature averaged 32 below. A recording thermometer indicated that within the compartment the temperature had reached a minimum of 8 below, and yet throughout, the operation of the lights had been completely satisfactory.

Last January, Canada experienced the severest cold recorded for 38 years, and yet Edison-equipped cars on the C. P. R. gave service that completely dispelled all fears on this score.

The ruggedness of the Edison battery becomes evident upon considering its mechanical features. It has been *proven* in the laboratory by allowing a cell to fall free half an inch one and three quarter million times onto a solid plank of hard wood without injury to the cell. This is not unimpotrant in car lighting service where there are occasional wrecks and frequent jolts due to coupling cars.

Chemical Impurities.

Chemical impurities are more harmful in an electrochemical combination, such as a battery, than in any other. This is because of the action of the current. Under the influence of the electric current, many inactive reagents become active, and when the current is periodically reversed the chemical action of many impurities is repeated at each reversal. It therefore becomes evident that time is an important factor as well as quantity. A small quantity of sulphuric acid, for example, in an Edison cell will do no harm if the electrolyte be quickly poured out, the cell carefully rinsed with water and refilled with fresh solution. But if the small amount be allowed to remain and the cell is kept in operation, the corrosive effect will sooner or later accomplish its evil work. It is for this reason that the use of pure distilled water for flushing must be rigidly insisted upon. It is the only kind of water upon whose constancy of purity can be depended. One reason for using the Edison battery is its long life—hence it is especially important to observe the strictest standards of purity, for the time element is great. This is particularly true in train lighting service, for even the partial removal of impurities that takes place when the solution is changed occurs at comparatively infrequent intervals.

Renewal of Solution.

Solution renewal is necessary when the electrolyte has become so weakened in service that after a full charge, with the solution level at the proper height, the specific gravity is below the limit prescribed in the battery instructions. Experience has demonstrated that this should ordinarily occur in from 18 months to 2 years. No solution should be allowed to remain in the battery for more than two years if used constantly because often the specific gravity is kept up through the presence of soluble impurities and a solution 2 years old is bound to have picked up more or less of impurities which should be expelled for the reasons previously explained. At the present time new electrolyte must be used for renewal, but it is not without the range of probability that it will sometime be found possible to rejuvenate old electrolyte at slight cost and use it over again.

Flushing the Battery.

Flushing with distilled water is necessary from time to time to make up for the loss of water that occurs through gasing while the battery is on charge. It should not be required in ordinary car-lighting service oftener than once every six or eight weeks. If it is, it is an indication that something is wrong—probably either overheating, overcharging, or both—and the trouble should be found and corrected.

One practice should especially be warned against, and that is the filling of cells with electrolyte when the solution is found to be unusually low. If it has become low by neglect, the added solution will increase the density to a point where the plates are likely to be subjected to dangerous strains, for gasing causes only water and not potash to be lost. Water should always be used unless it is positively and beyond doubt known that the solution became low through spilling.

In service, such as car-lighting, where the battery is not constantly under the care of one man, but is handled today by one man at one place and tomorrow by another man at another place, it is especially necessary to eliminate danger to the apparatus or to the continuity of operation by explicit rules, like the above, that "play safe." Another variable that enters into the operation of storage batteries, particularly under conditions of continually changing attendance, is the state of charge or discharge at any particular time. A driver of a storage battery truck or railway car who knows his car can make a pretty good guess by what he calls the "feel" of it. His judgment is contingent upon his running day after day the same vehicle with the same battery. In car lighting no such condition exists and it is therefore highly desirable from the standpoint of service and economy to provide positive means of knowing just what net amount of current has gone to or from the battery.

Ampere-hour meters, with a display of much ingenious skill, are now available which provide this information at all times under just such intermittent charging and discharging as is met with in railway lighting, taking full account of the ampere-hour efficiency of the battery. That the railroads are adopting the ampere-hour meter is a good sign.

Insulating the Trays.

I have previously mentioned that Edison cells and trays are coated with a protective insulating paint. It is hard to understand what a problem it has been to find a paint that meets all the required conditions of adhesiveness, non-brittleness, elasticity and alkali-resisting ability. The matter has been gone into with great care and from time to time it has been possible to improve upon the product employed in one direction or another without sacrificing some other quality. It is believed that the compound now in use comes very close to having all the desired properties. Several commercial paints, however, have been approved for this purpose, as it is often convenient or desirable for the user to purchase as he chooses. The paint is, of course, for the purpose of protecting the cells from grounds and electrolysis.

A very recent development, also along this same line, is the adoption of a tray which provides support for each cell on hard rubber at four or eight points, according to the size of the cell, and leaving the bottom entirely free. Metallic bosses of ample proportions, spot-welded to the sides of the can, fit into recessed hard rubber buttons in corresponding positions in the tray slats and these are the only points at which the cells are in contact with anything except the necessary electrical connectors. The trays may have bottoms or not, according to individual requirements, but in any case the cells will not touch or be supported at the bottom.

Now, a word as to the service. The straight storage and axle generator systems are the principal ones at present in use, and of the two the latter is the more popular.

Straight Storage System.

The straight storage system is ideal from the battery point of view, but usually is inconvenient from an operating standpoint. With it, full charges and discharges are possible and full normal charge rates can be maintained. The constant potential or tapering rate method of charging is being used in at least one yard with notable success. In this method the voltage is held at such value as will give a gradually tapering current, the average of which is about the normal rate of the cell. The initial current is, of course, considerably above normal and the final rate is low. If the only source of current available is of higher potential than that required, a fixed resistance must be placed in the circuit with the result that a flatter current curve will be obtained. The simplicity of this method, together with other advantages derived from the fact that the finishing rate is low, thus reducing the gasing, the required frequency of flushing and the waste of current through overcharging, will finally I believe, win great favor wherever straight charging is used. At the present time there are in the neighborhood of 20,000 Edison cells in straight storage service. The balance, with the exception of a few in head-end service, are used in connection with axle generator systems.

Axle Generator System.

The latter system possesses many advantages over others and evidently in the opinion of the majority of operating men they overbalance the contending advantages of the other systems. There is every reason to believe that in time the characteristics of the straight storage method will be so nearly approached as to leave no choice as far as battery conditions are concerned. The trend is in that direction. It is not improbable that a scheme will be successfully worked out whereby the advantages of constant potential charging will be available with the axle machine.

One of the chief faults of axle charging comes from the tendency to reduce the available charging rate as far below the normal charging rate of the battery as possible. The reasons for this desire on the part of designers and operators are obvious, but sight should not be lost of the fact that low rate charging is in general not satisfactory. It has the temporary effect of—to a certain extent—reducing the discharge voltage of the battery. It has been found necessary to recommend charging at not less than normal rate. At first two-thirds normal was the prescribed minimum, but that had to be changed for the following reason. In automobile work charging is done usually at night and it is customary for the garage man to stop in his other duties every half hour or so—if he thinks of it—inspect the ammeters in the charging circuits and adjust the rheostats. The current between readings, of course, always falls below the standard to which it was previously set and if this standard is two-thirds normal, the average is obviously considerably less. This explains why two-thirds normal rate worked in the laboratory and always appeared to fail in service. As the same conditions are prone to exist in all kinds of service, the policy of always insisting upon at least normal rate was adopted. This is a little inside information which you gentlemen, as engineers, are welcome to, but you are urged not to forget the explanation that goes with it.

The Edison battery is a favorite with those whose desire it is to be battery inspection experts without going to the trouble of developing a good memory. There are just three things to remember:

1st: The solution must be kept at a proper level.

2nd: The compartment and battery must be kept clean and dry.

3rd: The electrolyte must be renewed when the specific gravity is low.

This does not mean, however, that inspection should be done in any but the most painstaking and careful manner. Short inspections at frequent intervals are better than long ones made less often. Some eastern roads have adopted, with gratifying results, the plan of inspecting for poor contacts, dirty cells, condition of compartment, etc. every time the battery is flushed, or—in other words—every six weeks or so. It is my understanding that individual cell tests need not be made oftener than about once in six months. Thus, many a stitch is taken in time.

In service the battery has substantiated all claims that have been made for it. The first train-lighting sets were installed a little more than five years ago. One of the very earliest of these was in a battery house fire about a year ago and was returned to the factory for repairs, because most of the rubber parts had been more or less completely destroyed. After the repairing was completed (and it had consisted only of replacing the rubber parts), the battery was put on test and, to a cell, it tested well above rated capacity—*this* after four years of service and a fire! All the others of those early sets have evidently escaped fires and have equally well survived the rigors of continuous service.

In 1912 there were about 8,800 Edison cells in use for train-lighting. Today that service is employing at least 60,000 cells, distributed among 80% of the railroads of the country, some of which use them to the exclusion of other types.

Practically all the cells that have been sold for this purpose are now in use, and the few that are not were injured in wrecks or through acknowledged abuse.

Do not let me give the impression that none have been returned for repairs. Some *have* been repaired, but in the aggregate they amount to only one-tenth of 1% of all the cells in the service. The trouble with these has been chiefly leaky cells, due partly to defective seam welds (and these are always repaired free) and partly to electrolysis because of faulty inspection.

As you all know, the battery is sold under a liberal guarantee—100% rated capacity for five years, and yet, to date, not a single claim has been made on the basis of the guarantee.

Questions on the Edison Battery

Answered by H. H. Smith at the July Meeting of the R. R. Elec. Club

After Mr. Smith's instructive address, the subject was thrown open for discussion and numerous questions of interest were brought up and answered.

Effect of Temperature On Capacity.

Mr. C. R. Gilman, Chief Electrician of the C. M. & St. P. R. R., referred to the Edison batteries operating on the Canadian Pacific and asked if it had been found necessary to install steam pipes for keeping the battery warm. Mr. H. G. Thompson, of the Edison Storage Battery Co., said that when the C. P. R. R. first considered using the Edison battery they thought it advisable to install steam pipes in the battery boxes, but the Edison Company recommended against this and cars were constructed without the steam coils, the battery boxes being simply made tight with wooden lining at the top, bottom, and sides. This company has over 30 sets in operation with the Stone car lighting system, two sets to a car, one set charging, while the other set is supplying the lamps. These batteries have survived two winters, running between Montreal and Vancouver, and on the 30 sets there have been only two failures, these being due in each case to loss of belt between Ottawa and Winnipeg. As soon as the batteries were charged they came back to normal voltage and capacity.

The question was then brought up as to what would prevent the storage batteries from freezing at the terminals when there are no facilities for charging. Mr. Thompson stated that under most severe conditions the battery might freeze, possibly solid. It has been found, however, that by turning on a few lights some time before time for departure the heating effect of this discharge current going through the battery will be sufficient to warm the electrolyte slightly, so as to put the battery in service. He stated that while under such severe conditions the Edison batteries might freeze, any other battery would freeze and give similar results. He stated that any scheme which would protect a storage battery from freezing in cold weather would be acceptable to us all.

Mr. G. B. Colgrove, Chief Electrician of the I. C. Ry., stated that they had obtained some interesting data on operating temperatures in connection with an Edison battery of a car running between Chicago and Waterloo, Iowa. Tests were made in the winter time with the outside temperature as low as 30 deg. below zero. Under these conditions it was found that the lowest temperature inside the battery box was 16 deg. below zero. The Edison battery, however, operated satisfactorily during that period of cold weather. The car stood for several hours at the Waterloo end and when the lights were first turned on after this interval, the voltage was lower than normal, but after the car was in operation a very short time, the voltage came right up and there was no trouble experienced on account of temperature.

Changing the Solution.

Mr. George R. Shirk, Chief Electrician of the Chicago Great Western, asked if it was necessary to change the electrolyte every two years as recommended by the Edison Company. He stated that he had an Edison battery which had been in service for over three years without changing the solution. He stated the solution was clean, the grids were clean, and the cells appeared to be in good condition. He asked if it was doing the battery any damage to let it go so long.

Mr. H. H. Smith, of the Edison Company, stated that he never liked to answer that question absolutely definitely. "We don't like to go around recommending to people that they go to the expense of unnecessary solution renewal. We would feel pretty happy if every electric vehicle man was able to operate his car for three years, or even one and one-half years, without renewing the solution; and the only reason we recommend a change at the end of two years in railway lighting service is because we do not want to get the owner into any trouble through something he knows nothing about.

"Now, there may be some small impurity in that battery that is doing just a little bit of harm every time it charges and discharges; and it may shorten the life of the battery, although it may even temporarily increase its capacity. But if you renew every two years, the expense for electrolyte is not high. You have paid a lot for your battery, and it is a good thing to hold on to that battery as long as you can, and not do anything to injure it."

Mr. Shirk then asked if it would be advisable to save the old solution in connection with rejuvenating scheme. Mr. Smith stated that this might be advisable, provided there is sufficient space available to give over to it. It at least does no harm. He stated that the soluble impurities in the electrolyte may keep the gravity up, therefore, the fallen gravity cannot always be depended upon in telling where a solution needs renewing.

As to the impurities which are harmful, Mr. Smith stated that in general, sulphates and the carbonates are bad for the battery. Chlorides also injure the plates to a certain extent. He recommended that the railroads submit to the manufacturer samples from various cells regarding which there is any doubt.

Method of Changing Solution.

Mr. E. W. Jansen, Electrical Engineer of the Illinois Central R. R., then asked as to what method was recommended for changing the solution. Mr. H. H. Smith stated the best method is to pour out about two-thirds of the solution and set it to one side; the cell containing the other one-third of the solution should then be shaken up thoroughly and whatever black sediment there is in the bottom of the cell can then be poured out with the solution. Put some more of the solution back into the cell, shake again, and pour that out, then put in fresh solution. He said that railroad men often found it more convenient to simply take the tray out and pour the solution along side the track; pour in some fresh and put the tray back in the car.

Mr. Colgrove asked if it would damage the battery to wash it out with a hose. Mr. Smith said if the hose is clean and the water not dirty, it will not injure the battery.

Mr. Pachaly, of the Rock Island, stated that in the second cleaning of an Edison battery quite a black deposit came out of the water. He asked if this was anything to worry about. Mr. Smith stated that he did not imagine it was, as a slight amount of the very fine black powder, which collects as sediment, will strongly discolor the solution.

Gravity of the Solution.

Upon being asked what was the normal and allowable variations of gravity, Mr. Smith stated that normal gravity is about 1,200, although in train lighting cells, where so much space for the electrolyte to evaporate is provided, and when the solution level gets down near the plates, a reading may be obtained sometimes as high 1.250 without damaging the plates. Also immediately after renewing the solution the reading may be in the neighborhood of 1.230. The proper way to measure gravity is to take a reading after full charge with the level at the right height, that is, about 3 in. above the top of the plates. Under these conditions the gravity should not go below 1.160, this may be considered as the minimum.

He also pointed out that immediately after flushing it would be impossible to get a correct reading of gravity because the heavy solution stays at the bottom and the water, which is lighter, remains on top. If it is necessary to take a gravity reading after flushing, charge the battery and give it a gasing overcharge for 15 or 20 minutes before reading the specific gravity.

Determining the End of Charge.

Mr. J. A. Andreucetti, C. & N. W. Ry., asked how it is possible to determine when the battery was fully charged. Mr. Smith stated that the only positive way of telling is by the ampere hour meter and the meter must be connected permanently in the battery circuit so as to record all discharge and subsequent charge. The meter automatically provides 15 to 20% overcharge to make up for battery losses. He stated that this was true of other types of storage batteries than the Edison and he predicted a much more general use of the ampere hour meter in car lighting service than in the past.

Probable Life of the Battery.

Mr. E. W. Jansen, I. C. Ry., asked how many cycles of charge and discharge the Edison battery will give in its life time. Mr. Smith said that it is hardly fair to his company to mention, in connection with train lighting, the cycles of charge and discharge used for endurance tests, as this test is very severe. It has been estimated that it is 2 or 3 times as severe as electric truck service and train lighting is perhaps only 1/3 or 1/4 as severe as trucking. He said that they had obtained in these tests 1,250 complete charges and discharges and in some cases as high as 1,500 cycles. In train lighting, however, a life of several times this number of cycles should be obtained.

In explaining the conditons of the endurance test referred to, he stated that the batteries are charged 7 hours at the normal rate and discharged at 33% overload, to one volt per cell. The battery is then short-circuited and allowed to remain so for half an hour or more. It is then immediately put on charge again. Two of these cycles are run every 24 hours without regard for temperature or any other condition.

Safe Limit Temperature.

Mr. G. R. Shirk, of the Chicago Great Western, asked what is the highest battery temperature allowable. Mr. Smith stated that 115 deg. F. is the maximum prescribed, but this is only for continuous operation; for short periods temperature much higher can be taken care of without injury.

In the endurance tests above mentioned, he stated that when the battery is short circuited the temperature goes so high that the solution actually boils, not from gasing, but from the high temperature due from the heat generated on heavy current flow.

Changing Solution.

Mr. Smith stated that the battery should be completely discharged and short circuited half an hour before the solution is renewed. In mixing up the alkaline solution it will, of course, get pretty warm, but it may be put into the cells at any temperature less than 150 deg. F.

When asked what would be the result of emptying out the solution before having completely discharged the battery, Mr. Smith stated that there would probably not be any direct result, at least such as could be noticed right away. He stated that the specific gravity is higher at the end of the discharge than at any other time and it is, therefore, apparent that there is then more active electrolyte in the solution than at any other time. Consequently the whole solution is more thoroughly removed if emptied when the cell is completely discharged.

Normal Rate.

On being asked what the normal rate of the standard train lighting battery is, Mr. Smith stated that the A-8-H train lighting cells have a normal current rate of 60 amperes.

Change in Gravity of Solution.

Mr. Wray, of the *Railway Electrical Engineer*, referred to the change in gravity of the solution, it being higher at the end of discharge than at any other time, and asked if there was any good explanation as to why this occurred. Mr. Smith said that at the present time this is one of the unknown things regarding the Edison battery. He referred to the fact that for 20 years we did not know that a lead battery in its normal operation formed a sulphate of lead within the plates on discharge, which was subsequently broken up on charge. He stated that there are many things yet to be learned about the Edison battery.

Ampere Hour Meter Indication of Charge.

Mr. J. R. Wentworth, of the Lake Shore, asked if the ampere hour meter would not give a false indication, provided the battery was in bad condition, local short circuited, etc. Mr. Smith stated that the Edison battery was as a general thing always in good health, but when any local short circuit occurred when the battery was discharged without this current registering on the meter, a false reading would, of course, be given. This, however, would be an isolated case and such trouble should not be allowed to go uncared for.

Effect of Low Rate Charging.

Mr. Colgrove, Chief Elec., I. C. R. R., asked if, when the battery is charged at lower than normal rate, it isn't possible to put in the full number of ampere hours and still not bring the battery up to full charge. Mr. Smith stated it is not advisable to charge the Edison battery at a low rate, as this would mean low voltage, both on charge and subsequent discharge; although if the full number of ampere hours are put into the battery at this low rate, the full battery capacity may be withdrawn, but at a lower voltage. The effective capacity is therefore less.

In reply to a question as to what is the lowest rate of charge than can be employed, Mr. Smith stated that the rate should be ⅔ the normal rate, except where the discharge is to be at a very low rate, such as in signal work and a few isolated cases of train lighting. He pointed out the fact, however, that if the initial rate is high, the final rate may be very much less than this minimum without reducing the effective voltage on discharge. This is what would be experienced when the battery is operated in connection with the constant potential system and under such conditions, the battery operation is very much the same as if it were charged at constant current of the full normal rate.

How Can You Tell Condition of the Battery?

Mr. J. Andreucetti, C. & N. W. R. R., asked how it would be possible to determine the condition of the Edison battery, assuming that it was received in the yard at a partly discharged condition. Mr. Smith again pointed out here, however, that the ampere hour meter is the only reliable means of telling directly the state of charge of the battery. He recommended that in such a case the battery be fully charged till the voltage ceased to rise for over a half hour period.

Mr. H. G. Thompson, of the Edison Storage Battery Co., said that the driver of an electric car "feels his battery." The man who is taking care of an Edison battery can after a time "feel" the voltage condition of his battery with fair accuracy. A good test is to turn on the lights and, after they have been burning for about five minutes, the brilliancy gives a fair indication of what the condition of the battery is.

Effect of High Rate.

Upon being asked what effect high rates have on the battery, Mr. Smith stated that their only effect is to heat the battery and this is the only limitation on high rate charging. If you watch the temperature and keep this down below 150 deg. the charging rate can be practically any value desired.

Battery Current Vs. Generator Current Regulation.

Mr. Wray asked if, since it was desirable, particularly at the start of the charge, to have the charging rate at least 2/3 of normal value, the constant battery current regulator should not be preferred to the constant generator current regulator. In the latter case, where the total generator output is maintained constant, the night rate of charging is often low, and since many runs begin in the evening, when the battery would be partly discharged, it would seem that the battery current regulator in which the current in the storage battery is maintained constant, regardless of the lamps in use, would be preferred to the former type.

Mr. Thompson stated that his company would not assume to say that battery current regulation, where the regular coil is placed in the battery circuit, was any better than generator current regulation, where the regulating coil is in the total generator circuit. He stated that there are several axle lighting equipments with constant current regulation on the market with 65 to 70 amperes capacity, which will take care of all ordinary car lighting load and supply ⅔ normal current to the battery, even under the least favorable conditions.

Effect of Solution Getting Below Top of Plates.

Upon being asked what the result would be if the surface of the solution is allowed to get half way down the plate, Mr. Smith stated that the density of current on the lower half of the plate would be doubled and the internal resistance and heating of the battery also doubled. He said that this was a source of injurious heating.

In reply to the question as to how the upper half of the plate above the solution would be affected, he said that this would be in no way injured. The only harm that could come to the battery would be through high temperature and also the high gravity.

The question was asked if this would not tend to break the rubber insulation. Mr. Smith stated that it probably would not, but the unequal heating of the plate might cause a straining effect within the tubes of the positive plate or where these tubes make contact with the grid.

What Happens When the Battery Fails?

Does the active material come out of the tubes in a manner similar to the erosion of active material in lead batteries?

In reply to this question Mr. Smith stated that in their laboratories they had run a few batteries down to complete destruction by the method of severe testing described above. Upon being carefully examined, these plates appeared to be just as good as they ever were, and the active material all seemed to be in place. He said that they have been experimenting with taking the active material out of the plates, treating it to and return it to active condition and replacing it in the plates. There seems to be some slow chemical change taking place in the active material in the plates after a great number of discharges and charges, but so far this has not been definitely determined, even with the most careful chemical analysis.

Effect of Corrosion of Terminals.

Mr. Colgrove, Ill. Cent. Ry., asked what the effect would be of the taper contact joints of the cell posts becoming rusted. Mr. Smith stated that it would reduce the terminal voltage of the cell somewhat as it introduces resistance at that point. He pointed out that this trouble could easily be located by feeling of the terminal posts. If a post is at all corroded or contact is poor, it will get hot very quickly. This can easily be remedied by removing the connector and cleaning the terminal post with a strip of fine sand paper drawn back and forth over the surface. The lug on the connector can be cleaned by folding a piece of emery cloth into a cone with the emery side out to about the taper of the lug, and if this is twisted a few times inside the lug it will remove all dust and corrosion.

Why Does the Gravity Fall Off With Service?

In reply to this question, Mr. Smith stated that this is due to a mechanical carrying off of the solution by gases emitted on overcharging. You will notice after a battery has been in use for some time that there is a slight coating on the tops of the cells. This is potassium carbonate and is formed by the akaline solution from the battery combining with the carbon oxide of the air.

The Best Way to Clean Battery Trays.

Mr. Wray referred to the fact that, as previously mentioned, carbonates in a battery were harmful and asked if care should not be exercised in preventing this collection of carbonate on the tops of the cells from getting into the battery. Mr. Smith said that where the filler caps are on tight there is no danger of this.

The tops of the cells can best be cleaned off by using either a water or steam hose, preferably the latter, and then thoroughly dry the cells and trays with a blast of compressed air.

Efficiency of the Edison Battery.

In reply to a question as to the efficiency of the Edison battery, Mr. Smith stated that on a cycle of full charge and subsequent complete discharge, it is about 60% in watt hours; but in service where short discharges are followed immediately by partial or complete charge, such as is usually the case in railway car lighting service, the efficiency would be well over 75% in watt hours. The ampere hour efficiency would be considerably higher than this, probably 80 to 85% in most car lighting service.

Local Action in the Edison Cell.

Mr. Wray referred to the local action in the lead battery, which caused discharge of individual cells, such as local grounds, lead tree formation, contact with mud at the bottom, chemical impurities in the electrolyte, etc. He asked what kinds of local action there are that cause the Edison cell to run down on standing. Mr. Smith said that, of course, grounds will run down any part or all the battery, depending upon where the grounds are located. He said, however, that there is no other chemical action which can go on within the cell which would run it down, except by direct chemical oxidation and anti-oxidation of the active materials.

The construction of the plate with heavy reinforced rubber separators and rubber bushings at the terminal posts makes it very unlikely that a short circuit can occur inside of the cell. If this does not happen, however, that cell will, of course, be run down by that short circuit.

What Causes Bulging of the Can.

In reply to this question Mr. Smith stated that this might be due either to gas explosion inside the cell, or stoppage of the gas vent. In the old type cells, where a separate vent and filler opening was provided, the valve in the vent was between two openings and once in a while, through an accumulation of potassium carbonate, the little valve would stick to the upper opening and completely close it. The subsequent liberation of gases on charging would develop high pressure inside the cell and cause the can to swell, bulging it from top to bottom.

If an explosion occurs, this takes place very suddenly in the space above the electrolyte. The can in this case is bulged only above the electrolyte level. So you can tell very easily if the swelling is due to stoppage of the valve or to explosion.

At the end of the meeting a hearty vote of thanks was extended to Mr. Smith for his excellent talk and for conducting this interesting discussion.

A Joker Serious.

To the Gen. Supt. M. P., —— Ry.

Dear Sir: I shall introduce a subject with which you are probably not concerned, but which I would ask you to refer to the proper department of your road.

This subject deals with a peculiarly awkward and clumsy term, introduced since railway cars were lighted by electricity. I refer to the term "electrically lighted," but which is hard to pronounce and instructively calls for a modification.

I note that the Southern, the C. & O., the Erie and other roads have cut this down to "electric lighted," which is hardly an improvement and has the additional objection of being ungrammatical.

Now, I have given this matter considerable thought and have arrived at the conclusion that the remedy can only be reached by the coining of a new and euphonious word, and would strongly advise that your road put itself into foreground of philological progress by using after this the word: "electrilluminated," that is, illuminated by electricity.

There may be some objection urged to the length of the word, but you will find it is shorter, by two letters, than "electrically lighted."

Then again the word can be reduced by one letter by omitting an l, and spelling it "electroluminated," in which case it would be derived from electro and luminated and not from electr-illuminated.

But I think that the term "electrilluminated" is preferable and certainly more euphonious than "electrically lighted."

Kindly ask the gentleman in charge of these matters to pronounce these two terms several times in succession, and he will promptly note the advantage of the word I suggested. All I ask is that he be perfectly sober while he does it, as he might get his organs of articulation dislocated, if not permanently put out of business.

E. L. SCHARF, Ph. D.,
2603 Mozart Place,
Washington, D. C.

School of Electricity

A Course of Training Prepared by the Pennsylvania Railroad for Its Employees

Lesson No. 15

Mathamatics Continued

To multiply a number when the multiplier consists of one figure only.

Rule 5:—*Write the figure in the multiplier directly under the first figure on the right, or units place, in the multiplicand. Begin at the right and multiply each figure in the multiplicand by the multiplier.*

Example:

Multiply 762 by 7.

Solution:

```
Hundreds Tens Units
   7      6    2   Multiplicand
               7   Multiplier
 ---------------
 5 3      3    4   Product
```

Write the multiplier under the multiplicand and draw a line beneath. Beginning at the right to multiply, 7 times 2 units are 14 units or 1 ten and 4 units. Write the 4 in the units place in the product, and reserve the tens to add to the next product. 7 times 6 tens are 42 tens, which, added to the 1 ten, equals 43 tens, or 4 hundreds plus 3 tens. Write the 3 in the tens place in the product and reserve the 4 hundreds to add to the next product. 7 times 7 hundreds are 49 hundreds, which, added to the 4 hundreds, equals 53 hundreds, or 5 thousands and 3 hundreds. The figures 5 and 3 are written in their proper places as shown in the above solution. The product is then 5334.

To multiply a number when the multiplier consists of two or more figures.

Rule 6:—*Write the multiplier under the multiplicand placing units under units, tens under tens, hundreds under hundreds, thousands under thousands, etc., and draw a line beneath.*

Begin at the right and multiply each figure of the multiplicand by the multiplier, writing the right-hand figure of each partial product so obtained directly under the figure in the multiplier which produced it.

Add the partial products together, and their sum will be the entire product.

Example:

Multiply 423 by 656.

Solution:

```
      4 2 3   Multiplicand
      6 5 6   Multiplier
      -----
    2 5 3 8   First partial product
  2 1 1 5     Second partial product
2 5 3 8       Third partial product
-----------
2 7 7 4 8 8   Product
```

6 × 423 = 2538; 5 × 423 = 2115; 6 × 423 = 2538.

The right-hand figure, 8, in the first partial product, 2538, is written directly under 6, the first figure in the multiplier, or the number multiplied by. The right-hand figure, 5, in the second partial product, 2115, is written directly under 5, the second figure in the multiplier. The right-hand figure, 8, in the third partial product, 2538, is written directly under 6, the third figure in the multiplier. The sum of these three partial products is 277488, or the product of 423 × 656.

When there is a cipher in the multiplier, multiply by it as well as by the other figures.

Note.—0 times a number equals 0. Thus: 0 × 2 = 0; 0 × 18 = 0; 0 × 154 = 0.

Example:

Multiply 258 by 203.

Solution:

```
    2 5 8
    2 0 3
    -----
    7 7 4
  0 0 0
5 1 6
---------
5 2 3 7 4
```

Example:

Multiply 636 by 403.

Solution:

```
      6 3 6
      4 0 3
      -----
    1 9 0 8
2 5 4 4 0
-----------
2 5 6 3 0 8
```

The work may be shortened when multiplying by a number containing a 0 by writing the first cipher of the partial product, then multiplying by the next figure of the multiplier and writing the partial product to the left of the cipher.

Example:

Multiply 2432 by 2004.

Solution:

```
      2 4 3 2
      2 0 0 4
      -------
      9 7 2 8
4 8 6 4 0 0
-------------
4 8 7 3 7 2 8
```

The **Significant Figures** in a whole number or decimal are those which remain after canceling all the ciphers at the right or left. Thus, the significant figures in 12400, .0124, or 1240, are 124.

Annexing one cipher to the right of a number multiplies it by 10; annexing two ciphers multiplies it by 100; annexing three ciphers multiplies it by 1000, etc.

When there are ciphers at the right of either the multiplicand or multiplier, or both, take the product of the numbers denoted by the significant figures, and place to the right of the product as many ciphers as are found at the right of both multiplicand and multiplier.

Note.—The figures are usually set down with the significant figures under each other, the same as though no ciphers were present.

Example:

352 × 140.

Solution:

```
  3 5 2
    1 4 0
  -------
1 4 0 8
3 5 2
---------
4 9 2 8 0
```

Example:

1260 × 340.

Solution:

```
  1 2 6 0
    3 4 0
  -------
  5 0 4
3 7 8
-----------
4 2 8 4 0 0
```

There is one cipher at the right of each of the multiplicand and multiplier; so two ciphers are placed to the right of the significant figures in the product.

Example:

Multiply 2600 × 180.

Solution:

```
 2600
  180
 ----
208
26
------
468000
```

In this problem, there is one cipher in the multiplier and two ciphers in the multiplicand; therefore, place three ciphers to the right of the significant figures in the product.

DIVISION.

Division is the process of finding out how many times one number or quantity is contained in another; it is the inverse of multiplication.

The **dividend** is the number to be divided.

The **divisor** is the number used to divide by.

The **quotient** is the result obtained by dividing one number or quantity by another.

A partial dividend is that part of the dividend used in obtaining a figure of the quotient.

The sign of division is ÷ and is read *divided by;* for example, 48 ÷ 6 is read 48 divided by 6. Another way to write this is $\frac{48}{6}$.

There are two methods of dividing numbers; namely, **short division** and **long division.**

Short division is the method in which only the dividend, divisor and quotient are written, and the operations are performed mentally. It is usually employed when the divisor consists of only one figure.

Rule 7:—*Begin at the left, divide each figure of the dividend by the divisor, and write the quotient beneath. If there is a remainder after any division, consider this as prefixed to the next figure of the dividend, and proceed as before.*

Example:

Divide 735 by 5.

Solution:

$$\begin{array}{l} \text{Divisor} \quad \text{Dividend} \\ 5)\ \underline{7\ {}^{2}3\ {}^{3}5} \\ \quad\ 1\ \ 4\ \ 7\ \ \text{Quotient} \end{array}$$

Begin at the left to divide. 5 is contained in 7 once, with a remainder of 2. Write 1 as the first, or left-hand, figure of the quotient, and consider the 2 as placed before the 3 in the dividend, making 23. 5 is contained in 23 four times, with a remainder of 3. Write 4 as the second figure of the quotient, and consider the 3 as placed before the 5 in the dividend, making 35. 5 is contained in 35 seven times, with no remainder. Write 7 as the third figure in the quotient. The quotient is then 147.

Example:

Find the result of 18928 ÷ 7

Solution:

$$\begin{array}{l} \text{Divisor} \quad \text{Dividend} \\ 7)\ \underline{1\ 8\ {}^{4}9\ 2\ {}^{2}8} \\ \quad\ \ \ 2\ \ 7\ \ 0\ \ 4\ \ \text{Quotient} \end{array}$$

Begin at the left to divide. 7 is not contained in the first figure of the dividend; so the first two figures are used. 7 is contained in 18 two times, with a remainder of 4. Write 2 as the first figure of the quotient and consider the 4 as placed before the 9 in the dividend, making 49. 7 is contained in 49 seven times, with no remainder. Write 7 as the second figure in the quotient. 7 is not contained in 2; so place a 0 as the third figure in the quotient and write the 2 before the 8 in the dividend, making 28. 7 is contained in 28 four times, with no remainder. Write 4 as the fourth figure in the quotient. The quotient is then 2704.

Long division is the method in which all the work is written out in detail, and is usually employed when the divisor consists of two or more figures.

When the divisor consists of two or more figures.

Rule 8:—*Draw lines on each side of the dividend, and place the divisor at the left. Find how many times the divisor is contained into the lowest number of left-hand figures of the dividend that will contain the divisor, and write this figure as the first figure of the quotient.*

Multiply the divisor by this figure; write the product under the partial dividend; subtract; and to the remainder bring down the next figure of the dividend. Divide as before and thus continue until all the figures of the dividend have been used.

Proof:—*Multiply the quotient by the divisor and add the last remainder, if there be any. The result will be the dividend.*

Example:

Divide 2046492 by 84.

Solution:

$$\begin{array}{r l} \text{Divisor}\ \ \text{Dividend}\ \ \text{Quotient} & \\ 84)2046492(24363 & \\ \underline{168} & \\ 366 & \\ \underline{336} & \\ 304 & \\ \underline{252} & \\ 529 & \\ \underline{504} & \\ 252 & \\ \underline{252} & \end{array}$$

84 is not contained in the first two figures of the dividend; so the first three are used. 84 is contained in 204, the first partial dividend, two times, with a remainder of 36. Write 2 as the first, or left-hand, figure in the quotient, and bring down the next figure in the dividend, 6, to the right of the remainder, 36, making 366, the second partial dividend. 84 is contained in 366 four times, with a remainder of 30. Write 4 as the second figure of the quotient, and bring down the next figure in the dividend, 4, to the right of the remainder, 30, making 304, the third partial dividend. 84 is contained in 304 three times, with a remainder of 52. Write 3 as the third figure in the quotient, and bring down the next figure in the dividend, 9, to the right of the remainder, 52, making 529, the fourth partial dividend. 84 is contained in 529 six times, with a remainder of 25. Write 6 as the fourth figure in the quotient, and bring down the next figure in the dividend, 2, to the right of the remainder, 25, making 252, the fifth partial dividend. 84 is contained in 252 three times, with no remainder. Write 3 as the fifth figure in the quotient. The quotient is then 24363.

Example:

Divide 750145 by 62.

Solution:

$$\begin{array}{r l} \text{Divisor}\ \ \text{Dividend}\ \ \text{Quotient} & \\ 62)750145(12099+ & \\ \underline{62} & \\ 130 & \\ \underline{124} & \\ 614 & \\ \underline{558} & \\ 565 & \\ \underline{558} & \\ 7 & \text{Remainder} \end{array}$$

62 is contained in 75 once, with a remainder of 13. Write 1 as the first figure of the quotient, and bring down the next figure in the dividend, 0, to the right of the remainder, 13, making 130. 62 is contained in 130 two times, with a remainder of 6. Write 2 as the second figure of the quotient, and bring down the next figure in the dividend, 1, to the right of the remainder, 6, making 61. 62 is not contained in 61; so place a 0 in the quotient, and bring down the next figure in the dividend, 4, to the right of 61, making 614. 62 is contained in 614 nine times, with a remainder of 56. Write 9 as the fourth figure of the quotient and bring down the next figure in the dividend, 5, to the right of the remainder, 56, making 565. 62 is contained in 565 nine times, with a remainder of 7. Write 9 as the fifth figure of the quotient. The quotient is then 12099+.

Note:—The sign, +, following a quotient is used to denote a remainder.

FACTORS AND FACTORING.

The **factors** of a number are those numbers which, when multiplied together, will produce that number. Thus: 2 × 3 × 5 = 30, therefore, 2, 3, and 5 are *factors* of 30.

Factoring is the process of finding the *factors* of a quantity.

An **exact divisor** of a number is an integer or whole number that will divide the number without leaving a remainder. Thus: 2, 3, 6, and 9 are *exact divisors* of 18.

A **prime number** is a number that has no factors except itself and 1. Thus: 2, 3, 5, 7, 11, 13 are *prime numbers.*

A **composite number** is a number that can be produced by multiplying together two or more numbers, each greater than a unit; as, 6, 8, 10, 15.

An **even number** is a number that is divisible by 2 without a remainder; as, 4, 6, 8, 10, 12.

An **odd number** is a number that is not divisible by 2 without a remainder; as, 3, 5, 7, 9, 11.

A prime number that is a factor of another number is a **prime factor** of that number. Thus: 2, 3, and 5 are the *prime factors* of 30.

An **exponent** is a small figure placed to the right of a number and a little above it, and shows how many times the number is used as a factor. Thus: in 4^3, the number ^{3} is the *exponent,* and shows that 4 is to be used 3 times as a factor, which is the same as writing 4 × 4 × 4.

Cancellation is a short method of division by rejecting the same factors in both dividend and divisor.

Rule 9:—*Cancel the same or common factors in both the dividend and divisor. The result obtained by dividing the product of the remaining factors of the dividend by the product of the remaining factors of the divisor will be the quotient.*

Canceling the same factor in both divisor and dividend does not change the quotient.

The numbers forming the dividend are placed above the line, and those forming the divisor are placed below it.

Example:

Divide 45 × 30 × 7 by 7 × 25.

Solution:

$$\frac{\overset{9}{\cancel{45}} \times 30 \times 7}{7 \times \underset{5}{\cancel{25}}}$$

Place the dividend, 45 × 30 × 7, over the divisor, 7 × 25. The 25 in the divisor and the 45 in the dividend are both divisible by 5, since 5 × 9 = 45, and 5 × 5 = 25. Cross off or cancel the 45 and write 9 over it, also cross off the 25 and write 5 under it as shown.

$$\frac{\overset{9}{\cancel{45}} \times \overset{6}{\cancel{30}} \times 7}{7 \times \underset{\underset{1}{\cancel{5}}}{\cancel{25}}}$$

5 in the divisor and 30 in the dividend are both divisible by 5, since 5 × 1 = 5, and 5 × 6 = 30. Cross off the 30 and write 6 over it, also cross off the 5 and write 1 under it as shown.

$$\frac{\overset{9}{\cancel{45}} \times \overset{6}{\cancel{30}} \times \overset{1}{\cancel{7}}}{\underset{1}{\cancel{7}} \times \underset{\underset{1}{\cancel{5}}}{\cancel{25}}}$$

7 in the divisor and 7 in the dividend are both divisible by 7, since 7 × 1 = 7. Cross off the 7 in the dividend and write 1 over it, cross off the 7 in the divisor and write 1 under it as shown.

Since there are no numbers left in both the dividend or divisor, which are divisible by the same number except 1, it is impossible to cancel further. Multiply all remaining numbers in the dividend together and divide this product by the product of the remaining numbers in the divisor. The product of the remaining numbers in the dividend is 9 × 6 × 1 = 54, and the product of the remaining numbers in the divisor is 1 × 1 = 1.

Therefore,

$$\frac{\overset{9}{\cancel{45}} \times \overset{6}{\cancel{30}} \times \overset{1}{\cancel{7}}}{\underset{1}{\cancel{7}} \times \underset{\underset{1}{\cancel{5}}}{\cancel{25}}} = \frac{9 \times 6 \times 1}{1 \times 1} = 54$$

Note: It is customary to omit the 1's when canceling.

Note: In solving problems in cancellation it is not necessary to show all the steps as above, these different operations being shown here to explain the various steps.

COMMON SYMBOLS.

The **parentheses** ( ), **brackets** [ ], **braces** { }, and the **vinculum** $\overline{\qquad}$, called **common symbols**, are used to include numbers which are to be considered together. Thus: 10 × (6 − 4), or $10 \times \overline{6-4}$ means that 4 is to be taken from 6 before multiplying by 10 These expressions are solved as follows:

$$10 \times (6-4) = 10 \times 2 = 20, \text{ or } 10 \times \overline{6-4} = 10 \times 2 = 20.$$

When + and − are the only signs in an expression, the operations are performed in the order in which they occur, beginning at the left. Thus: 4 + 6 − 7 + 3 = 6.

When ÷ occurs in an expression in connection with +, −, or both, the indicated division must be performed first.

Example:

7 + 10 ÷ 5 = ?

Solution:

The division is performed first; as, 10 ÷ 5 = 2; then, 7 + 2 = 9.

When × occurs in an expression in connection with +, −, or both, the indicated multiplication must be performed first.

Example:

5 × 3 − 2 = ?

Solution:

The multiplication is performed first; as, 5 × 3 = 15; then, 15 − 2 = 13.

When ÷ and × are the only signs in an expression, or are succeeding signs in a series, the indicated multiplication and division are performed from left to right in the order in which they occur.

Example:

7 + 6 − 8 ÷ 2 × 3 = ?

Solution:

8 ÷ 2 = 4; 4 × 3 = 12; 7 + 6 = 13; 13 − 12 = 1.

PROBLEMS.

Note: These problems should be answered one or more complete lessons at a time.

FIRST LESSON.

1.—Write out in figures by the Arabic system the following: (*a*) Seven thousand two hundred fifty-five; (*b*) One million seventy-five thousand one hundred four.

2.—Write out in words the following: (*a*) 1705; (*b*) 5673.

3.—How many hundreds in (*a*) 2 thousands? (*b*) 5 thousands? (*c*) 50 tens?

4.—Express the following numbers by the Roman system: (*a*) Twenty-seven; (*b*) Sixty-eight; (*c*) Three hundred forty-five; (*d*) One thousand six hundred forty-five; (*e*) Five thousand six hundred forty-three; (*f*) Forty-five thousand four hundred thirty-two.

5.—Write out in words the following numbers: (*a*) CDXII (*b*) MDCCLXXVII.

SECOND LESSON.

6.—Find the sum of (*a*) 734 + 241 + 123 + 390; (*b*) 1096 + 6824 + 1365 + 2341.

7.—Find the sum of (*a*) 1635 + 26 + 18072 + 5 + 2612; (*b*) 10625 + 2345 + 23 + 267521 + 9871.

8.—(*a*) A car travels 231 miles on Monday, 176 miles on Tuesday, 192 miles on Wednesday, 201 miles on Thursday, 181 miles on Friday, 76 miles on Saturday, and 159 miles on Sunday. What was the car mileage for the week? (*b*) If the car in the above problem had traveled 5 miles additional each day, what would have been the car mileage for the week?

9.—The resistances of 4 telegraph relays are 435, 375, 392, and 410 ohms, respectively. What is the sum of their resistances?

10.—One man's wages amounted to $96 for the month, 2 men receive $75 each, and 3 men receive $60 each. What is the total amount of their pay?

THIRD LESSON.

11.—(*a*) From 7362 take 6151; (*b*) from 125634 take 24313.

12.—Find the result: (*a*) 9137 − 8038; (*b*) 123065 − 70076.

13.—(*a*) From 1264 + 2335 + 726 subtract 3416; (*b*) From 622 + 1236 + 9475 + 36 subtract 8964 + 23.

14.—(*a*) From a coal pile containing 110,560 pounds, one engine took 7240 pounds, another 5630 pounds, and a third 6450 pounds. How many pounds of coal remained?

(*b*) From a keg containing 725 bolts, there were taken at different times 47, 35, and 60 bolts, respectively. How many bolts remained?

15.—A train going from New York to Pittsburgh in the first hour traveled 48 miles, the second hour 42 miles, the third hour 45 miles, the fourth hour 35 miles, and the fifth hour 31 miles. How far is the train from Pittsburgh at the end of the fifth hour, the distance between New York and Pittsburgh being 440 miles?

FOURTH LESSON.

16.—Multiply (*a*) 12694 × 8; (*b*) 52762 × 7.

17.—Multiply (*a*) 21456 × 45; (*b*) 93762 × 96.

18.—Multiply (*a*) 7625 × 4398; (*b*) 6452 × 3761.

19.—If it requires 124 tons of steel worth $25 a ton to build one mile of railroad track, what will be the cost of the steel to build a track 235 miles long?

20.—How many miles will an engine travel in a year if it makes a trip from New York to Philadelphia (90 miles) and back every day except Sunday? There are 52 weeks in a year.

FIFTH LESSON.

21.—Find the quotient of (*a*) 2640 ÷ 6; (*b*) 21204 ÷ 9.

22.—Find the quotient of (*a*) 18096 ÷ 29; (*b*) 224250 ÷ 6.

23.—Find the quotient of (*a*) 3635152 ÷ 536; (*b*) 11657070 ÷ 2907.

24.—If the driving wheel on a locomotive is 18 feet in circumference, how many revolutions will it make in going from Philadelphia to Pittsburgh (350 miles)? There are 5280 feet in a mile.

25.—How many rails each 33 feet long will be necessary to lay a piece of track 24 miles long?

SIXTH LESSON.

26.—Find the prime factors of (*a*) 325; (*b*) 2310.

27.—Find the value of (*a*) (860 + 980 − 1120) ÷ 45; (*b*) (320 − 98) × (860 − 145).

The Railroad Electricians' Club

Meetings the 3rd Monday of Every Month, 8 P. M.—18th Floor Transportation Bldg., Harrison and Dearborn Sts., Chicago—Everybody Welcome—No Dues

Lead Storage Battery Questions

Prob. 1. We rate a battery in terms of ampere hours. Most car lighting batteries are of about 300 ampere hours capacity. What does this mean? What is an ampere hour?

Ans. 1. An ampere hour is a measure of the quantity of current represented by a current of one ampere flowing for one hour. It is the product of amperes and time. A current of 5 amperes flowing for two hours would then represent (5 times 2, or) 10 ampere hours. A current of 10 amperes for one hour, or 2 amperes for 5 hours, would also represent 10 ampere hours. When we speak of a 300 ampere hour lead battery, we usually assume that this is going to be discharged in 8 hours and the current (300 divided by 8 or) 37½ amperes is known as the normal rate.

Prob. 2. What makes the voltage of a storage battery vary? Why is it necessary to charge at a much higher voltage in the winter time, provided you keep the current constant, than it is in the summer time?

Ans. 2. The voltage of a lead battery varies with the state of charge of the battery. It also varies with change in temperature, change in gravity of electrolyte, current rate, condition of the plates, etc.

Obviously the greater amount of charge in the storage battery, the higher will be its voltage, assuming other things equal. A warm battery charges at a lower voltage and discharges at a higher voltage than a cold battery. A battery with electrolyte at normal, strength 1220, will give a higher discharge voltage and require a lower charging voltage than a battery with electrolyte of abnormally low gravity. This is due both to the increased internal resistance of the battery with weak electrolyte, and also to the scarcity of sulphuric acid where the plates are sulphating normally on discharge. It is pretty evident also that the heavier the discharge current taken from a battery, the less will be its voltage, due partly to the internal resistance of the battery opposing the flow of current, but chiefly due to the change in chemical conditions of the active material in the plates.

As to the high charging voltage of a battery in the winter time, this seems to be due chiefly to the sluggishness with which the acid comes out of the plates when a cold battery is being charged. The surface material becomes reduced readily enough, but it seems to require a higher voltage to bring out the acid from the material below the surface when the battery is very cold than when charged at normal temperature (70° F.). When a battery is charged at constant potential, so that the current tapers off at the end, this high charging voltage in cold weather is not so apparent.

Prob. 3. What is meant by constant current charging?

Ans. 3. This is where the charging current is kept at a constant value all the time the battery is being charged. This rate is usually about the normal rate of the battery which, as explained in problem No. 1, is 37½ amperes for a 300 ampere hour battery.

Prob. 4. What is meant by constant potential charging?

Ans. 4. In this method of charging, the storage battery is connected to a circuit of constant potential. As soon as the circuit is closed the current usually runs up to a high value since the counter electro motor force of the battery is weak at the start. The lower the state of charge, the higher will be this initial current. This counter electro motor force, however, rises as the battery charges, due to the change in condition of the plates, and opposes the flow of current, causing it to be reduced gradually as the charge proceeds.

Where a constant potential of proper value has been selected the charging current will taper off to a very low value at the end of charge. In many cases, automatically coming down from 120 amperes at the start to from 5 to 10 amperes on a 300 ampere hour battery at the end of charge.

Prob. 5. Why does the gravity of electrolyte of a lead battery go down on discharge and rise on charge, always coming back to the same point at the end of charge?

Ans. 5. One of the fundamental principles in the operation of the lead storage battery is that when it is discharged the sulphuric acid in the electrolyte goes into the plate and combines chemically with the active material, forming what is called soluble lead sulphate. The amount of acid in the plates then represents the amount of current which has been discharged from the storage battery. On charge this acid is driven out of the plates back into the electrolyte.

On discharge then when the acid goes into the plates it weakens the electrolyte and on charge, when it is driven out of the plates back into the electrolyte, it against strengthens the electrolyte. Since all of the acid is driven out of the plates when the battery is fully charged, the gravity at the end of charge should always come back to normal value.

Prob. 6. What makes the voltage, is it the plates or the electrolyte?

Ans. 6. It is both plates and electrolyte that generate the voltage. As we well know, if the electrolyte leaks out of a cell it will generate no voltage whatever. Even though electrical connection be established between the plates, by touching them, there will still be no voltage result. It takes both the active material of the plates and the acid of the electrolyte to produce the electric current, just as it takes both coal and oxygen of the air to produce heat.

Prob. 7. What is the difference between the pasted type plate and the Plante type plate?

Ans. 7. Pasted type plates are made by covering a grid made of antimony-lead alloy with a paste made chiefly of litharge or red lead. This paste of red lead, which is the most highly oxidized form of lead oxide, is later reduced by the electric current to lead peroxide for the positive plates and lead sponge for the negative plates.

Plante type plates on the other hand are made by simply taking a sheet of soft lead and corrugating the surface one way or another, so that it is converted into a multitude of thin leaves of meallic lead connected to a central rib. This gives the plate a great surface for the acid to act on and when it is treated in certain chemicals, known as the "forming agent," by charging and discharging, this surface of the lead becomes oxidized to peroxide, this forming a spongy coat or layer over the entire surface of the plate. All plates are first formed as positives and the negative plates are subsequently made by discharging the positives and reversing them, charging them as negatives. This reduces the lead peroxide first to lead oxide when the battery is discharged, and later to lead sponge, when the current is reversed, which is the active material of the negative plates.

Prob. 8. Can you have a storage battery made up of both pasted and Plante type plates?

Ans. 8. A storage cell can be made with a plante negative and a pasted positive, or a pasted negative and a plante positive.

Prob. 9. What is meant by the growth or formation of Plante plates?

Ans. 9. In service the metallic lead in the thin ribs of the plate continues to change slowly into lead peroxide and replaces the active material worn away from the outside of the plate. In the pasted type plate, however, there is no formation of the metallic lead other than a very slight coating on the surface.

Prob. 10. Do you have this same growth in pasted plates. If not why not?

Ans. 10. All the material except the grid is already formed into active material and the grid being a hard lead alloy with antimony resists the forming action; even after a pasted plate is completely worn out the grid is still found to be solid and in its original form.

Prob. 11. Suppose you take a group of Plante positives and put them into a tank with another group of Plante positives instead of regular negative plates and charge the two. What will happen? Will this make a good battery?

Ans. 11. When you put two positive elements in the same tank there should be little or no voltage if the plates are in the same state of charge. When such a combination is connected up, and charging current forced through it, the elements which are connected to the positive pole will, of course, be fully charged at the start, so gasing will take place on the positive plates all through this charge.

At the negative plates, however, hydrogen will be given off by the flow of current and this will in turn re-act on the peroxide of the active material and first reduce it to lead oxide and then further reduce it to spongy lead, which is the active material of an ordinary negative plate. After all of this active material has been reduced to spongy lead, the cell is a regular plante cell with normal positive and negative plates and will give full voltage and capacity on discharge.

Prob. 12. How do the temperature changes from summer to winter conditions affect the battery voltage on charge and discharge?

Ans. 12. When a storage battery is cold, as explained in problem 2, there is less chemical activity between the plates and the electrolyte and the diffusion of the electrolyte (mixing of the strong electrolyte at the bottom with the weaker electrolyte at the top) is greatly reduced. This makes all of the chemical changes in the battery less active, which causes a decrease of voltage on discharge and an increase in charging voltage, assuming the current rate be kept constant.

Extreme cold seems to reduce the speed at which the acid can go in or out of the plates. If the battery is charged or discharged at a very low rate, however, so that the speed with which the acid diffuses in and out of the plates will be sufficient to take care of that discharge current, the low temperature will not affect either the charge or discharge voltages appreciably. This explains why the charging voltage of storage batteries operating in signal work, when they are charged at a very low current rate, does not change to any appreciable extent, even at extremes of temperature.

Voltage variation with temperature then depends chiefly on the current rate.

Prob. 13. How do temperature changes affect battery capacity?

Ans. 13. When we rate a battery at say, 300 ampere hours, it means that it will give 300 ampere hours when discharged at the 8 hour rate. The end of discharge is determined by the voltage falling off to 1.8 volts. There is, of course, a considerable number of ampere hours capacity still remaining in the battery, but it is not considered advisable to discharge the battery below this voltage. Voltage is then the limiting factor in determining battery capacity.

In cold weather, as explained above in problem 12, if the discharge rate be high there will be a rapid falling off in voltage, due to the sluggishness of the cold battery, so that the voltage of 1.8 volts per cell will be reached sooner than it ordinarily would at normal temperature. The full battery capacity may be in the battery, however, but on account of the falling off in voltage this capacity may not be available at the normal current rate.

If the battery is discharged at low current rates, however, as explained in problem 12, the discharge voltage will not be appreciably affected by the low temperature and the battery will give its full capacity. This may or may not be the total rated capacity of the battery, depending upon its condition.

Problems for Next Month

Lead Battery Questions.

Prob. 14. What is the highest temperature at which it is safe to operate a lead battery?

Prob. 15. What is normal gravity?

Prob. 16. What are the safe limits for gravity of the the electrolyte?

Prob. 17. Why does temperature affect gravity? Is this of enough importance to be taken into consideration in practical work?

Prob. 18. I read gravity on a cell as 1,240 with the temperature 10 above zero Fahrenheit; is the gravity of the electrolyte above normal?

Prob. 19. Another battery shows gravity of 1,220 at 105 deg. Fahrenheit; is this gravity too high?

Prob. 20. In making up electrolyte for storage batteries how much acid and water do you put together?

Prob. 21. Do you pour the electrolyte into the water, or the water into the electrolyte? What difference does it make, and why?

Prob. 22. Why is it necessary to add water to all cells of the storage battery occasionally?

Prob. 23. What damage will it do if the surface of the electrolyte is allowed to get below the tops of the plates?

Prob. 24. Why do you add just water and not acid?

Prob. 25. Will any kind of water do for flushing batteries?

Prob. 26. What is the mud that collects in the bottom of battery tanks; is it cinders, dust, or lead formation?

Prob. 27. How thick can you let this mud collect before the battery requires cleaning?

Prob. 28. How are you going to find out how thick the mud is?

Prob. 29. Is there any other way you can tell when a battery needs cleaning?

A. B. C. Car Lighting Course

Edited by Edward Wray

The first lesson of this course was published in our Feb., 1912, issue. All back numbers covering over two years' work can be furnished, bound in heavy paper covers with special binding arrangement, so that future lessons can be added and preserved. This also includes all back lessons of the P. R. R. School of Electricity, the R. R. Electricians' Club, Prize Question Box, and Practical Stunts. Price $1.00. (*See blank on page* 6.)

Lesson No. 31

Type "L" Consolidated Axle Equipment with Ampere Hour Meter Control

During this course of lessons it will be remembered that we have from time to time referred to the subject of controlling the operation of axle lighting generators by means of the ampere hour meter. Accordingly, it gives us pleasure, and is a source of no little satisfaction, to be able at this time to describe the actual application of this principle of control to one of the standard car lighting systems.

The equipment is essentially the same as that described in our lesson No. 20. The metallic resistance segments in the generator field circuit are controlled by a rocking contact shoe, operating over a commutator of special design, the bars of which connect to the various segments of resistance. The degree to which this shoe is rocked will depend upon the train speed. Operating normally the proportion of lamp load picked up by the generator can be adjusted by means of a set of contacts, shown at the top of the panel Fig. 171, by means of which all, 2/3, 1/3 or none of the lamp current can be picked up by the generator. In other words, the equipment can be made to operate as a simple constant current device, in which the generator current remains constant regardless of lamp load, or it may be set to operate as a battery current regulator, in which the current flowing into the battery is maintained constant and the generator load increased with the lamp load; or it may be operated as a combination of these two, in which the generator picks up part of the load.

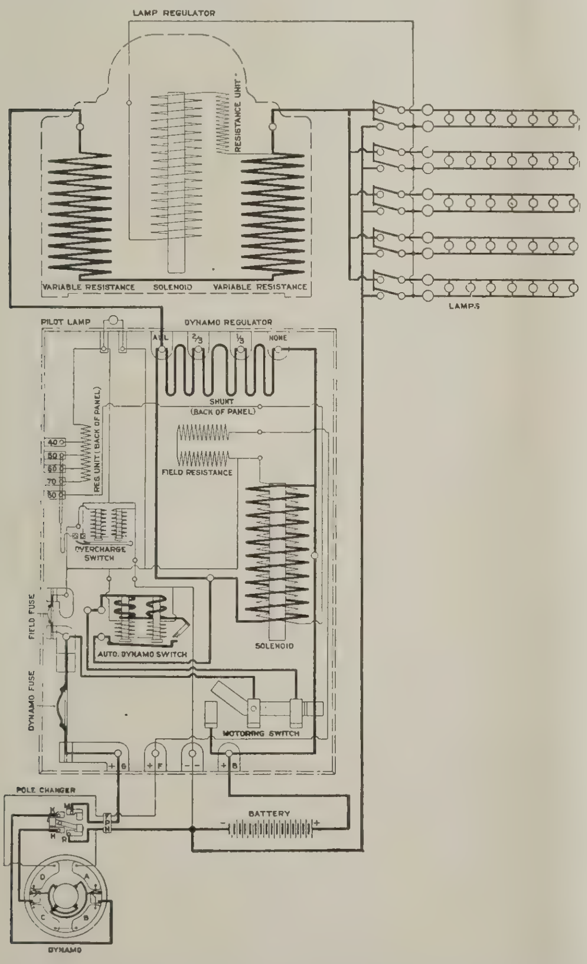


Fig. 171. Wiring Diagram of Consolidated Axle Equipment

Ampere Hour Meter Control.

An ampere hour meter of the variable resistor type is employed to measure the number of ampere hours charge and discharge which the battery receives. The meter dial hand revolves in a clockwise direction on discharge and the reverse direction on charge. As described in our Lesson No. 26, March, 1914, the meter is so adjusted that it runs slower on charge than on discharge by any desired percentage. It has been considered advisable to set this so as to provide 20% overcharge; in other words, assuming a battery efficiency of 83½%.

In order to best understand the operation of the meter we will follow an equipment for one trip. When received at the station the meter shows a discharge of 10 ampere hours, and while standing in the station one hour discharges 25 ampere hours more, so that the meter dial reads 35 ampere hours discharge when the train pulls out. We will assume that the regulator is set to pick up all of the lamp load, and also provide a constant current of 40 amperes flowing into the battery; the machine will then begin to charge the battery at this rate after getting up to speed. During the course of the next hour we will assume there were 3 stops aggregating a total of 15 minutes, representing about 6 ampere hours discharge. This makes a total discharge, then, of 41 ampere hours. As the battery is charged the dial hand will move back toward zero but at a slower rate by 20% than it did on discharge, so that by the time the dial hand gets back to zero the battery will have been given a charge of 41 ampere hours plus 20% or, 49 ampere hours.

When the dial hand gets back to zero it will make a contact which, if the battery voltage is up above a predetermined value (between 37 and 42 volts) will reduce the battery charge to a very low value. By comparing the wiring diagram in our Lesson No. 20—on the type "L" regulator without the ampere hour meter modification, and that in this lesson with the ampere hour meter control, it will be seen that a resistance unit has been added to the overcharge switch circuit. This makes it so that the overcharging switch will not operate unless the voltage goes up to 49 volts, which would represent open battery circuit conditions.

When the ampere hour meter makes zero contact, however, it simply short circuits this resistance and allows additional current to flow through the coils of the overcharge switch, causing it to operate and prevent further charge. Even though the ampere hour meter may show zero contact, the battery voltage must be above a predetermined battery charging voltage of 37 to 40 volts (as may be selected), or the magnetism generated in the overcharge switch coils will not be sufficient to close that switch. Under these conditions, the equipment will continue to operate normally until the battery gets up to this voltage.

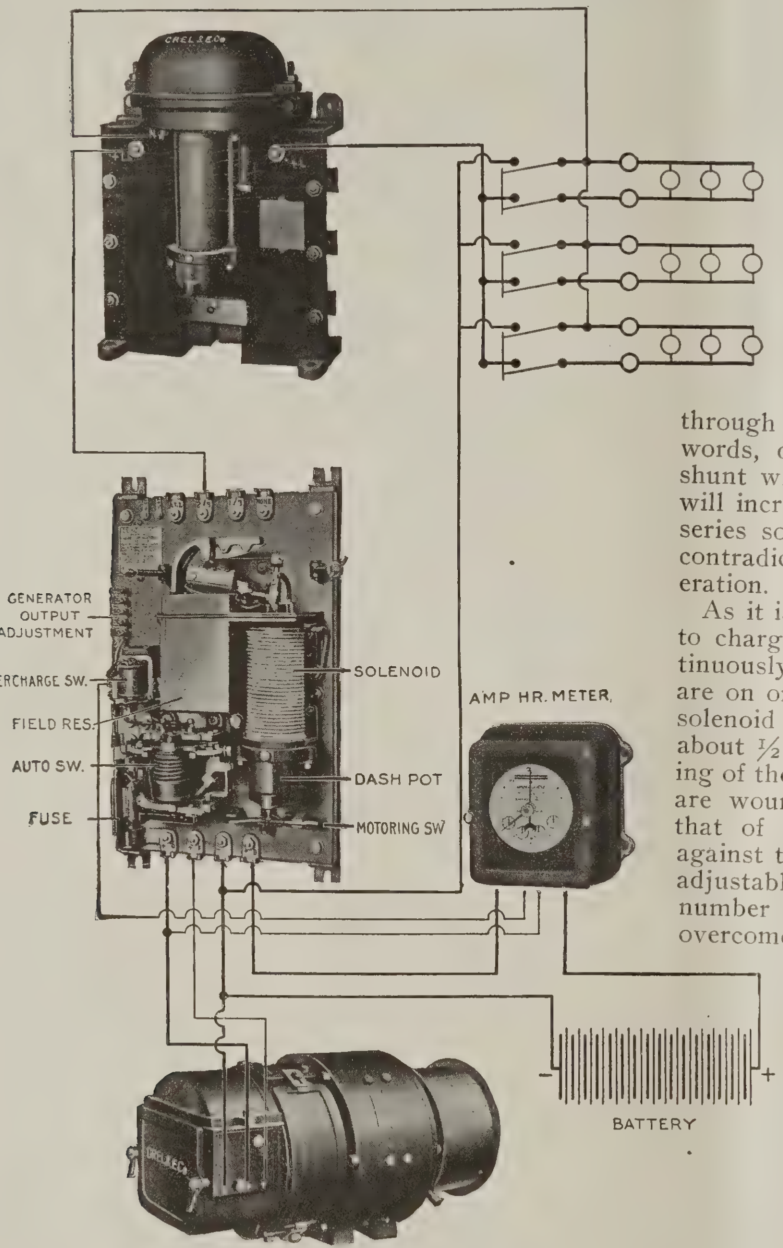


Fig. 172. Diagram Showing Connection of Units of the Consolidated Type "L" Equipment. Note the Ampere Hour Control.

In this combination of meter contact controlling the operation of the overcharge relay, the one acting as a check on the other, the battery is thus charged for a certain number of ampere hours and then if the voltage has risen to proper value the charge is discontinued.

When the overcharge switch operates, due either to the zero contact in the ampere hour meter, or to high voltage with open battery circuit, the adjusting resistance that is in series with the potential coil of the main solenoid is short circuited, allowing full generator voltage to be impressed across it. This strengthens the solenoid and causes the generator to operate at floating voltage.

As the train slows down to the next stop the overcharge switch drops open, cutting in the resistance and restoring normal operation of the equipment. At the next stop the battery may discharge slightly, which may or may not be sufficient to move the dial hand of the meter so as to break contact. In any event, however, the equipment will continue to operate, charging the battery until the zero contact in the meter is restored and until the voltage of the battery rises to the predetermined voltage of 37 to 40 volts.

Adjustment.

There are some unique features about the output adjustment of this equipment which are worthy of mention. The current flowing through the series solenoid of the regulator is adjusted to any desired value by adjusting the current flowing through the shunt winding of the regulator. In other words, decreasing the current flowing through the shunt winding by inserting resistance in that circuit will increase the battery current flowing through the series solenoid. This, to some, may seem almost a contradiction, so we will endeavor to explain the operation.

As it is shown in the diagram, the equipment is set to charge the storage battery with 50 amperes continuously all the time it is operating whether lamps are on or not. This current flows through the series solenoid of the regulator. A very weak current of about ½ an ampere also flows through the fine winding of the shunt solenoid of the regulator. These coils are wound so that the magnetism of one adds to that of the other and the combined pull balances against the pull of the spring which is fixed and nonadjustable. In other words, it always takes a certain number of ampere turns of magnetizing force to overcome the pull of this spring and operate the regulator. These ampere turns are supplied part by the series coil, and part by the shunt coil.

When we decrease the current flowing through the shunt coil by cutting in resistance in its circuit, it will decrease the total number of ampere turns magnetizing force generated by that coil. This will then require that a larger number of ampere turns be supplied by the series coil in order to keep the total number of ampere turns constant and provide a magnetic pull sufficient to overcome the regulator spring. Since the total number of turns is constant, an increase of ampere turns required from the series coil, will cause an increase in the current flowing through that coil.

In order to adjust the equipment then, it is simply necessary to plug in the small connection at 40, 50 or 60, etc. (as desired) in the row of plug holes shown at the left hand side of the panel, Fig. 171. This cuts in or out resistance in the shunt coil circuit, as explained above.

This adjustment of current output should not be confused with the dynamo shunt regulator shown at the top of the board. This latter simply adjusts the proportion of the lamp current picked up by the generator. When it is set on the "all" point, as shown in the diagram, the current is fed directly from the auto switch to the lamp regulator without passing through the regulator coil and the generator current thus increases by the full amount of lamp current turned on. The battery current alone then flows through the windings of the series coil of the regulator and is maintained at a constant value, regardless of lamp load.

If the top contact is made at the "2/3" position on this shunt, 1/3 of the lamp load will pass through the regulating coil and 2/3 will pass directly from the auto switch to the lamp regulator. If contact is made at the 1/3 point, 1/3 of the lamp current will pass direct to lamps and 2/3 through the regulating coil. The generator will then pick up 1/3 of the lamp load, increasing its output by 1/3 of the lamp load and the current to the battery will decrease by 2/3 of the lamp current.

Motoring Switch.

One of the chief causes of trouble with automatic switch contacts burning is due to the fact that when motoring the equipment in the yards the generator is connected to the battery by closing the automatic switch by hand, and after the generator gets up speed the circuit is broken by opening the automatic switch; this causes rather severe arcing at the switch contact points.

To obviate this difficulty a motoring switch has been added to this equipment, which connects the generator directly to the storage battery and the circuit through the automatic switch and regulating solenoid is opened, so that the current used to motor the generator comes direct from the battery and does not flow through either the automatic switch or the regulator. The connections of this switch will be observed by following out the wiring diagram of this system.

The manufacturers of this equipment state that since applying this motoring switch on their equipments 7 months ago they have not had a single case of automatic switch failure, and, as is well known, this is a not unusual cause of trouble in axle generator systems.

Prize Question Box

This "Question Box" is open to every electrical man in the Mechanical, Signal and Telegraph, as well as Car Lighting Departments. We feel that this can be made a mighty valuable thing, so as a special inducement to the boys to boom it, we offer prizes for the best questions asked, as follows:

First prize	$1.00 *in cash*
Second prize	9 *months' subscription*
Third prize	6 *months' subscription*

There are some questions that are of a general nature, which should have comments of prominent men of experience. These will be published under "Questions Before the House," and we hope that prominent railroad men and manufacturers will discuss these questions. All answers published will be paid for at $1.00 *each.*

Questions Before the House

A Question on Battery Flushing.

I have two sets of batteries running in same train and flush both on the same date. At the end of a period of thirty days I make inspection of both sets, and have usually found that one is down to top of plates, while the other is good for twelve days or more. Which set of batteries is in normal condition? The number of lamps and hours of service on both cars are the same. CBF Pullman Electrician.

Reversed Axle Generator Fields.

No. 8—I recently investigated a trouble report on an axle equipment in which the machine on arrival was reported to have reversed fields; this occurred several times within one month. On first investigation, no apparent cause could be found; later while motoring the machine, however, I accidently opened the battery switch and on again attempting to motor the machine, found fields reversed.

Would opening the battery while motoring cause the fields to reverse?—A. V. Westervelt, B. & O. R. R.

Rise in Battery Voltage on Charge.

If the voltage of a battery on open circuit be a given amount, say 2.0 volts per cell, and charging current is sent into it, would the potential raise at the battery terminals be equal to the drop due to internal resistance of the battery?

Motoring E. S. B. Dynamo.

"How do you motor an E. S. B. Dynamo?"—M. F. Hand, Santa Fe.

For the Axle Light Man to Think About.

No. 9—Some time ago one of our new coaches equipped with a Gould axle device with B. B. generator regulator arrived in Boston with a light failure. The field carbon pile was hot and the potential coil was warm. From appearances it looked like battery trouble. The battery was given a good charge and a discharge. On discharge it stood up to its rating, 300 ampere hours. The machine motored both ways and when speeded up the carbon pile being quickly compressed, the voltage generated by the revolving armature closed the automatic switch.

I rode the car on its next trip out to see how it would act under service conditions. Here is a log of test taken while enroute when train speed was approximately 20 miles per hour:

Automatic switch lifted until carbon contacts hardly came together; the lever arm, which is actuated by the potential coil, started to raise, releasing the pressure on field carbons; the meter registered 38 volts at 5 amperes. This condition remained the same even when train was going at high rate of speed. After waiting 15 or 20 minutes to see if there was any change, I pressed down very slightly on the lever arm and the automatic switch closed tightly and machine put up 50 amperes at 38 volts. After train came to a stop and started up again, the regulator worked the same way.

What caused the trouble?—Lester B. Knight, Boston & Albany R. R.

First Prize

Axle Generator Alignment.

In an axle-lighting equipment, why is it that, when a dynamo is out of level compared to the car axle to which the axle-pulley is attached, that, when the car is moving in one direction the belt will run to one side of the dynamo pulley, but, when the car is running in the opposite direction, the belt will run to the other side of the dynamo pulley?

In this connection I would like to have you explain also why it is that, when a pulley is crowned, the belt will stay in the center of the pulley running to the high point, but, when the shaft of the dynamo is not parallel with the car axle, the belt will run to the low side; or the side nearest the car axle.

I am enclosing sketches showing the different conditions.

S. W. Everett.

To the Editor:

In your January issue Mr. S. W. Everett asked the following question: "Why does a belt run to the crown of the pulley and also why will a belt when the shafts are not parallel run to the low side of a pulley?"

You answered this question, but I wish to submit the following answer, as I differ somewhat from your answer:

In answer to the first question, refer to Fig. 1. This shows the shafts of two pulleys parallel to each other. One pulley is crowned and the other is not. The belt comes in contact with the crowned pulley on the line A. B. The rotation of the pulley is as shown by the arrow. The point of the pulley marked "1" will travel in the direction shown by the arrow and a quarter of a revolution will reach the point marked 2. If there is no slipping on the belt the edge of the belt that comes in contact with the pulley at point 1 will move to point 2, which is nearer the center of the pulley than point 3, which was the edge of the belt when the quarter of the revolution started. This creeping to the high point of the pulley will continue until the belt balances on the crown.

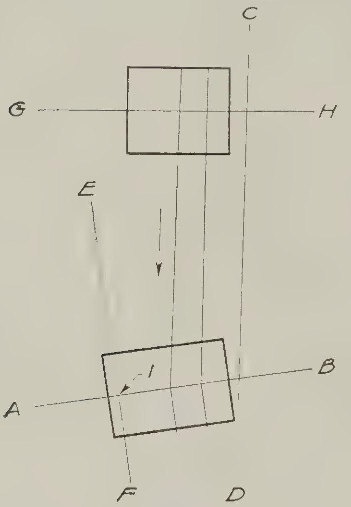


Fig. 2.

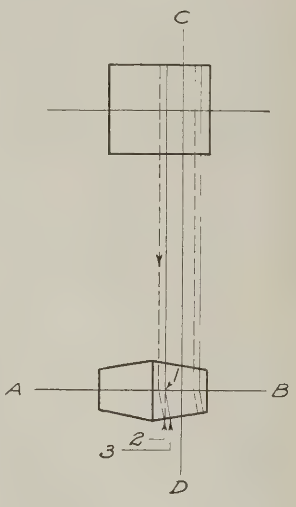


Fig. 1.

In answer to the second question as to why, in case the car axle and armature shaft are not parallel the belt will run to the low side of the pulley, refer to Fig. 2, which shows the car axle G. H. and the armature shaft A. B. The line C. D. is drawn at right angle to the car axle G. H. The line E. F. is drawn at right angle to the armature shaft A. B. With the direction of rotation as shown by the arrow, that is the top side of the belt, moving toward the dynamo pulley any point, as No. 1 on the upper half of the dynamo pulley will move in a direction with the line E. F. From "E" toward "F." The line C. D. is at right angle to the line G. H. and the line E. F. is at right angle with the line A. B. Since G. H. and A. B. converge the line C. D. and E. F. must converge and any point moving in the direction of the line E. F. must move closer to the line C. D.

Both these answers assume that there is no slipping of the belt. A. E. Voigt, Asst. Electrical Engineer, Santa Fe.

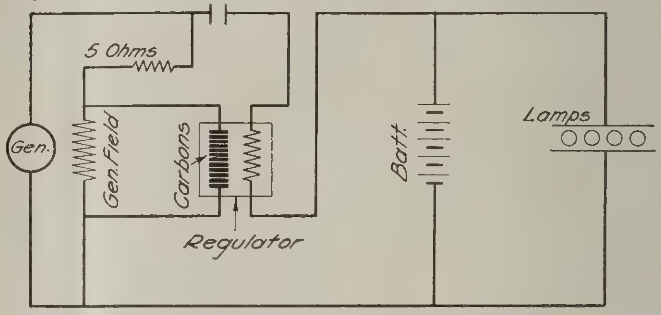
Second Prize

Current in Moskowitz System.

No. 4. Why does the current run up on a Moskowitz equipment as the speed of the train increases? That is, if the dynamo is set for 30 amperes when the train is running at 30 miles an hour and when the speed of the train increases to 50 miles per hour, you will find that the output of the machine has raised almost double, to perhaps 45 or 50 amperes.—A. E. Voigt.—Santa Fe.

The reason why the current increases in a Moskowitz system when the train speed increases over that at which the regulator is adjusted, is made clear by the consideration of the following facts:

The generator field is connected in series with a fixed five-ohm resistance. As the train speed increases more current tends to flow. The field current is, however, partly shunted through a carbon pile, connected in parallel with the fields. The resistance of the carbon pile is varied by a lever operated by a solenoid connected in the armature circuit. As the carbon pile is compressed the voltage across the field terminals is lowered by drawing an increased amount of current through the five-ohm resistance and the voltage drop across the same. The same action, however, takes place in the carbon pile and its voltage drop is similarly increased. While the net result is a decrease of the field strength, this decrease is not proportional to the increase in speed of the dynamo.



Wiring Diagram of Moskowitz Equipment

J. L. Ohmans, C. & W. I. R. R.

Third Prize

The Effect of Using a Dirty Hydrometer.

Q. I find that in lead storage battery work, after reading gravity on a number of cells, you take a piece of clean waste or paper and carefully wipe off the dirt that has accumulated on the hydrometer and take a new reading of the same cells, it will be found that they are from 3 to 10 points lower than formerly. Which is the correct reading, and why does wiping the hydrometer make the difference?—E. J. Galloway, Oakland, Calif.

Ans. If the dirt on your hydrometer is grease or saw-dust, or any other substance lighter than water, it would tend to float the hydrometer, giving a higher reading than it should; but on the other hand, if the dirt which adheres to the hydrometer is heavy dirt such as sand, etc., which would ordinarily sink to the bottom of the lectrolyte, it will have a tendency to sink the hydrometer deeper into the solution and so give a lower reading than it should. Evidently the dirt on your hydrometer was grease, as you got a lower reading after you wiped it off.

The hydrometer should always be kept clean and free from dirt of all kinds in order to get correct readings. Furthermore, don't foget to take the temperature into consideration as this changes the gravity about one point for every 3 degrees fahrenheit above or below 70 deg. In other words, if the electrolyte is at 90 deg. and gives an indication of 1,220 the gravity reading at normal temperature (70 deg.) would be 1,227, since the temperature is 20 deg. above normal and ⅓ of 20 is about 7, which added to the 1,220 reading you obtained gives the corrected reading of 1,227. The same rule works the other way for temperatures below normal. For instance, if you have a temperatue of 10 above zero; this is 60 deg. below the normal temperature and represents a drop of 20 points. In other words, electrolyte which showed a gravity of 1,240 at this temperature, would be only 1,220 at normal temperature of 70 deg.

Excessive Heating of 110-60 Volt Train Lighting Generators.

The turbine driven generators in our head lighting service were changed from 110 volt to 60 volt operation a few years ago. When this was done an extra resistance unit was placed in the shunt field of the generator and a shunt of proper resistance connected across the compound field Some of the machines give serious trouble due to overheating and the men report that this seems to be caused by the shunt on the series field.

It is possible to operate the generator without this series field shunt when lamps alone are connected as a load on the generator. But when the batteries are connected, regardless of their conditions of charge, the voltage of the machine is very difficult to control without the shunt on the compound field.

Why should these generators heat excessively, and why should it be possible to control the voltage without the shunt when lamps alone are on the generator, but be impossible to do so when batteries, with or without lamp load, are connected?—C. R. Gilman, Chief Elec., C., M. & St. P. Ry., Milwaukee, Wis.

In designing compound wound generators the ampere turns in the series field with full load current flowing are made a certain percentage of the ampere turns of the shunt field so as to produce a certain number of volts rise when the load is changed from no load to full load. These generators you refer to were originally designed for 110 volts, that is the compound field winding is made of such a number of turns that with full load current flowing through it, it would give a rise of about 8 volts.

When these machines were changed to operate at 60 volts a resistance was added in the shunt field circuit, which greatly reduced the current flowing through the shunt field. This not only increased the relative proportion of series ampere turns to shunt ampere turns by about 2 times, but because of the fact that under 60 volt conditions the generator fields were operated well below the saturation point, the added magnetising force of the series field, which normally would produce only an 8 volt rise on full load with the field saturated, would now have a much greater influence and produce a far greater rise in the voltage. For this reason it was necessary to shunt away some of the current from the series field winding in order to reduce the effect of this winding in about the same proportion that the shunt field magnetism had been reduced in changing from 110 to 160 volt operation.

Although with lamps alone in circuit it might be possible to operate these generators with full series field, that is without any shunt whatever, since this added voltage would simply cause a slight increase in current through the lamps; but when the storage batteries are on the line, the rise in voltage would incidentally cause a very heavy surge of current through the storage batteries and as the current through the batteries would rise, the series field would be inceased still greater and the voltage rise higher, which in turn would cause still further rise in battery current until the generator circuit breaker would go out. In other words the combination with batteries in circuit would be an unstable one where the shunts across the series field were omitted.

Practical Stunts

We Pay a Dollar Apiece for Practical Stunts—Send in Your Ideas

A Sparkless Lighter for Hydrogen Burners.

An automatic gas lighter which operates without spark or flame can be made as follows: Saturate a piece of asbestos two by three inches with 5% solution of platinic chloride and dry gently with hydrogen flame until asbestos turns black. Then direct flow of hydrogen gas onto the asbestos and it will ignite. This lighter will last indefinitely.

L. D. Smith, Rock Island.

Battery Plate Press.

Take an air cylinder, an 8 in. or 9 in. one will do, remove the base plate from the back end and bolt a piece of iron 1 in. thick by 10 in. by 16 in. in its place, call this plate No. 1. Drill a hole in the center of this plate for the air connection, also drill one 1 in. hole in each corner.

Make another plate the same size as No. 1, call it No. 2, drill holes in each corner the same as No. 1, and fasten this plate to the end of the piston. Now make plate No. 3, the same size as the others with the holes in each corner.

Take four rods 36 in. long with the ends 4 in. long on each end. Space plate No. 3, 31 in. from No. 1, and connect it to No. 1 with the long rods, let plate No. 2 slide on the rods.

To straighten a set of plates, put in spacing blocks between plates and place in press. Then turn on the air and the press will quickly flatten and straighten the plates.

This press will not be needed with the E. S. B. Company's Manchester positives used with either a box or shelf negative. J. E. Millard.

Easy Rule for Estimating Electrical Input to Motors.

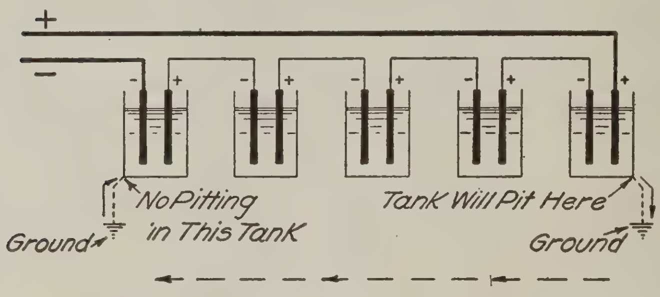
The rule that the k. w. input to a motor is approximately equal to its horsepower output and is a convenient way of measuring the power required to drive a motor where the horsepower of the driven machine is known. If the k. w. input is known, however, this is approximately equal to the output of the motor in horsepower.

This reasoning, of course, assumes that the motor efficiency is 74.6%, since 746 watts equals one horse power. This is considerably less than the full load efficiency of large motors, but it must be remembered that the efficiency of a motor decreases very much at the lower loads, so that 74.6% is a fair average for all conditions. This rule will often be found of value for it is very often desired to know what horse power is required to run a certain machine. The actual measurement of the horse power is difficult, but it is easy enough to measure the k. w. input to the motor.—H. M. Nichols, Reading, Mass.

Why Certain Battery Tanks Pit More Than Others

It is very frequently found that certain tanks of a storage battery will have a chronic habit of pitting and even though these tanks be replaced with an entire new tray, new elements, etc., the new tank will soon become pitted. This point has been discussed in the Question Box and Practical Stunts column in previous numbers, but I believe that the main point has been overlooked.

By referring to the accompanying diagrams it will be seen that in order to have any trouble caused from grounds there must be at least two grounds, one positive and one negative, in order to complete the circuit and allow current to flow. It is not necessary that these grounds be near the terminals of the battery, they may be on two trays near the center of the battery, but there must at least be a positive and a negative point in order that current flow from one tank lining through its ground, thence through the negative ground to the tank lining, which is nearer the negative terminals of the battery. Under such conditions the tank which is near the positive end of the battery will be the one to pit and even though there be a heavy ground on the tank at the negative end and a heavy current flowing through that ground to negative, it will not pit the tray, as this current would have simply a reducing action, tending to deposit metal and prevent oxidation of the lead at the ground on the positive side, the current leaving the tank and flowing to the ground will form peroxide of lead and pit the lead lining of the tanks at that point.



Where trouble is experienced with tanks pitting there is always at least two grounds. In repairing the trouble it is not sufficient to simply replace the leaky tray with a new one—always find the other ground and remove it before you consider the trouble cleared. —Otto Hildebrand, Edison Storage Battery Co.

Test for North and South Pole.

With a mild current flowing through the field coils, take two pieces of soft iron (not tempered) about 2 in. long, or a couple of iron nails and place one end of each piece on adjacent pole pieces, bring the other ends of the nails or iron pieces near together; if a strong pull of magnetic attraction is then felt between the ends of the nails the two adjacent poles are north and south respectively. If there is very little or no magnetic attraction between the ends of the nails, it indicates that both the poles are the same, either both north or both south and that one of the field coils is accordingly connected wrong.

In order to determine which one of the field coils is connected wrong, test all of the other poles in the same way. You will probably find that between one of these two poles tested and another pole there is the same lack of attraction as between the first pair. This would indicate that all these three poles so tested are the same, so the coil on the middle pole should be reversed. When this field coil is reversed, test all the poles again and if a strong attraction is felt between each pair of poles, the connections are probably O. K.

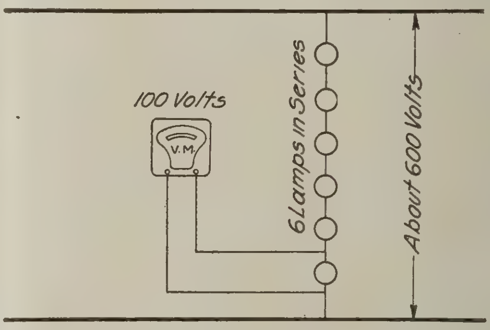
I say probably, because the connections may be all wrong. If there was a very bad mixup so that every field coil in the generator has been reversed by this process, the generator will show O. K. on this magnetic test, but when the armature is put in place and brought up to speed the generator will develop the wrong polarity. If this is the case all field connections should be reversed.

This method has the advantage over the compass method for a person can usually pick up nails or pieces of iron around the yard, while a compass is not always available.—W. B. Hoschke.

Measuring 600 Volts on a 100 Volt Meter.

It very often occurs that a man wants to measure the voltage of a circuit which is higher than the reading of any meter which he has on hand. The accompanying sketch will illustrate how this may be done with an ordinary low scale voltmeter.

Suppose for instance it is required to measure the voltage of a 600 volt circuit and only 0.125 volt meter is available; take six 110 volt lamps and connect them in series with each other and connect them to the line as shown, then with the volt meter measure the voltage across each one of the lamps. The sum of all these individual voltages will be the total voltage of the circuit. This method is entirely satisfactory on d. c. or a. c. circuits, provided the voltage does not fluctuate. If accurate readings are desired, the full set of readings should be taken about three times and strike the average total.—F. G. Montreal, Canada.



Sketch Showing Arrangement of Lamps and Connection of Volt Meter

Where the Editor Got Mixed.

To the Editor:

Being an interested reader of the RAILWAY ELECTRICAL ENGINEER, I beg to call your attention to what appears to me to be a mistake in the answer to problem 25, page 59, in the July issue under the "Railroad Electricians' Club." The answer to this problem ("What elements determine the resistance of a wire") says: "It is obvious that a big wire will have greater resistance than a small one," and again in the answer to Problem 26 is this statement: "It is self evident that the smaller the wire the less will be the resistance."

Now I believe that these two statements are somewhat mixed, for it is a well-known fact that the greater the size of the wire the less the resistance and the smaller the wire the greater the resistance.

N. E. Collins, Orangeville, Ont., Can.

You Know Him.

That car lighting man who hasn't yet subscribed to the *Railway Electrical Engineer*. Tell him what he's missing and to send in his dollar.

Summer Vacation Notes

August is vacation month, or it ought to be (it "ought to be," for us); when we get as far away from the grind and our troubles as a combination of railroads, steam boats, and overland coaches can get us.

A party made up of railway electrical men was organized recently in Chicago, Cleveland and St. Louis for a week end fishing? expedition, way down in the middle of the State of Missouri. The men were: "Lou" Hensel, Frisco, "Harry" Pfeffer, Missouri Pacific, "Joe" Wray, Frisco, "Geo." Colgrove, Illinois Central, "Joe" Andreucetti, C. & N. W., "Harry" Meloy, Lake Shore, "Ches" Luckey, Edison Storage Battery Co., "Billy" Bauer, Edison Storage Battery Co., "Dick" Haley, U. S. L. & H. Co., "Dick" Bowler, Cotton Belt, "Billy" Williams, S. C. H. & L. Co., "Si" Hopkins, S. C. H. & L. Co., "Charlie" Gelan, Oliver Elec. Co., "Henry" Myers, Pullman Co., "Charlie" Hooper, Std. Htg. & Vent. Co., "Charlie" Streeper, Wabash, J. Hassett, S. C. H. & L. Co.

Some of the Car Lighting Boys in the Backwoods of Missouri

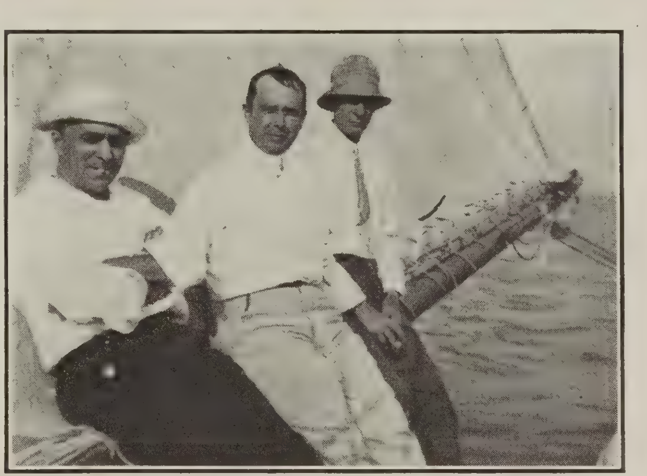
"Billy" Bauer Gets a Hopeful Nibble

They said they caught some fish and had one picture with a poor little fellow to prove it, but the picture of the fish was so small he wouldn't reproduce well, so we didn't use that one.

Off for a Cruise on the "Nomad"

Cruise of the "Nomad"

There sure was "no mad" individual aboard her that beautiful afternoon a couple of weeks ago when she slipped out of the Chicago inner harbor with a gallant crew of a dozen or more car lighting experts aboard. A brisk southwesterly wind drove her along at a good rate, yet the breeze was directly off shore so was not able to stir up enough of a swell to make it uncomfortable for the near sailors.



Sailor Lads Yo-ho!

G. H. Atkin, alias "Tommy Atkins," was the skipper host and J. H. Burcham, C. & E. I., "Bert" Myers, Santa Fe, "Alex" Voigt, Santa Fe, Topeka, "Joe" Andreucetti, C & N. W., R. T. Milton, O. R. Shorthall, and H. F. Marsh, Electric Storage Battery Co., and Edward Wray, of the *Railway Electrical Engineer,* shipped as crew. All voted it was the best time of the summer.

General News Section

Ernst Lunn Appointed Chief Elec. Pullman Co.

Mr. Ernest Lunn, who has for the past eight months been retained as consulting engineer by the Pullman Company in connection with its electric car lighting equipment, has recently been appointed chief electrician of the Pullman Co., in charge of all electrical equipment.

Mr. Lunn has for many years been the storage battery engineer of the Commonwealth Edison Co., and in this capacity has been directly in charge of the operation of all the storage batteries of that company, aggregating a total capacity of 25,000 k.w. on the one hour rating. He has also acted as consulting engineer for the Walker Vehicle Company, manufacturers of electric trucks. Among storage battery men, Mr. Lunn has the reputation of being one of the best storage battery engineers in the country.

It was at his suggestion that the ampere hour meter was originally developed in 1908, and this has subsequently proven to be of inestimatable value in all classes of storage battery work. During the past few months several hundred ampere hour meters have been employed for controlling the operation of axle car lighting systems on Pullman cars with most gratifying results.

A thorough investigation of rates, floating voltages, battery ampere hour efficiency in car lighting service, etc., is being carried out and we hope to be given permission to publish some of this information at an early date, as it will no doubt be of great interest to all car lighting men in this country and abroad.

U-S-L Management and Staff Retained.

In the United States District Court in Buffalo on July 21st, Judge Hazel appointed James O. Moore and James A. Roberts receivers for The U. S. Light and Heating Company following a case in equity. That it was a case in equity and not in bankruptcy was made evident in the hearing.

It was clearly outlined by the Court that there should be no interruption in the fulfillment of existing contracts, in the prosecution of pending business or in the company's operations in any department.

Mr. A. H. Ackermann, vice-president and general manager prior to the receivership, was immediately appointed general manager to operate the business because of his familiarity with it, and the entire staff of salesmen, engineers, etc., were retained in their former capacities.

Mr. Ackermann has issued the following statement to the trade and to the public:

"The action recently sustained in the appointment of the receivers for the property of the company was a necessary step to conserve the assets for the benefit of all. With assets of three dollars for every dollar of debt, the company is amply stable, and the Court's direction to continue the business is the last proof necessary to reassure the buying public. There are already under way plans for broad financing, and with the return of general prosperity in the country, the USL, more aggressive than ever before, intends to secure its own full share of the business and to continue the manufacture and sale of its special electrical products."

C. H. Quinn Appointed Elec. Eng. of N. & W. Ry

Mr. C. H. Quinn, formerly mechanical engineer of the Norfolk & Western Ry., has recently been appointed electrical engineer directly in charge of all electrical matters on that road.

As has been mentioned from time to time in the *Railway Electrical Engineer*, the N. & W. Ry., are now electrifying the Bluefield-Vivian division, about 85 miles in length, on the western slope of the Allegheny mountains. This is probably the heaviest electric traction scheme proposed in the world, and the locomotives to be employed are an innovation in electric locomotive practice as they employ a phase converter, on the locomotive, which converts the single phase current into three phase current. All the advantages of light weight, high power, and regenerative control of the three phase motor and the flexibility, cheapness of construction and great range of action of the high voltage single phase system are combined in this system selected.

Electrical engineers all over the world will watch with interest the working out of this new idea in electric locomotive practice, in which Mr. Quinn is the man behind the gun.

Westinghouse Strike Ended

The Westinghouse strike was called off by the workmen themselves on July 9th. Although Monday, the 13th, was the day set to return to work, a large number of men reported to work on the Friday and Saturday preceding and the works are now running full time.

I. E. S. Convention.

The eighth annual convention of the I. E. S. will be held at Cleveland in the Hollenden Hotel Sept. 21st to 25th. The convention's business sessions and the annual reception, ball and banquet will be held in this hotel.

Terry Turbines for Italian Navy.

Last year's order of nineteen turbines for the Italian navy of the Terry Turbine Co. was duplicated this year by an order for thirty-two more. This with North American orders including twenty for the Philadelphia Electric Co. has made it necessary for them to increase the capacity of their plan about twenty-five per cent.

New Consolidated Axle Light Bulletin

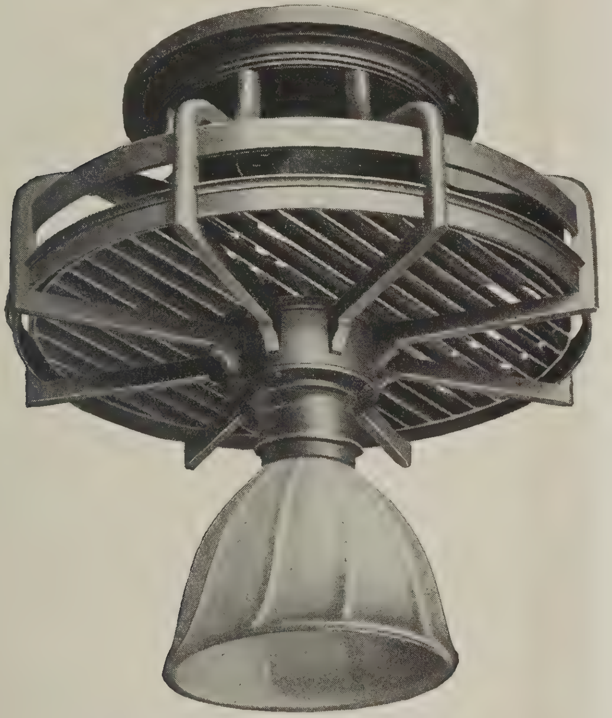
The Cons. R. E. L. & E. Co., of Hanover Bank Bldg., New York, has just issued a new bulletin describing their type "L" regulator with the ampere hour meter control modification. This equipment is fully described in the A. B. C. car lighting course of this issue.

The bulletin is very attractively gotten up and may be had upon application to the Consolidated Co.

New Principle in Railway Car Ventilation

The evolution of the fan from the palm leaf to the modern electric fan is but coincident with the development of electricity as a motive force; and the progress made in electric fans has, therefore, largely centered in the design of electric motors. What is needed in this field is somewhat analogous to the requirements in the field of artificial illumination, since the control of generated light and the control of generated air velocity are equally important for the best utilization of expended energy. Photometry and reflector design have brought about a wonderful degree of efficiency in modern illuminating practices, and it is reasonable to expect similar progress in the circulation of air, provided adequate study is given the problem.

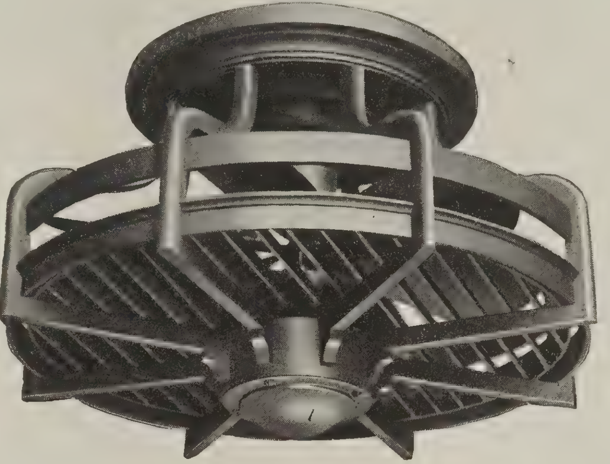
We were brought to a fuller realization of the possibilities in this field by a new type of fan for railway cars exhibited by the Safety Car Heating & Lighting Company at the recent railway convention held at Atlantic City. Here we had demonstrated what can be accomplished by a careful study of means to control the direction as well as the velocity of air currents generated by electric fans; and what has already been accomplished by this new type of fan augurs well for future progress.


New Combination Car Fan and Lighting Fixture

From the old type disc fans, blowing a steady gust of air in a fixed direction, to the oscillating disc fans and the gyrating disc fans has been a step forward toward directing air currents over a large area; but these types have reached their limitations. This new type of fan, however, provides for air circulation within a predetermined zone and in any predetermined direction at frequent intervals and at velocities to suit different requirements.

The principal feature in the design of this fan is the use of an air deflector revolving under a disc fan. This deflector consists of a series of planes within a circular frame and geared to the motor shaft so as to produce a breeze at desired locations once every three seconds. For railway cars the fan is designed to give the greatest velocity to the air movement within a zone of between 30 degrees and 45 degrees to the perpendicular and tapers to zero at the perpendicular or nadir and at an angle of about 60 degrees to the perpendicular, thus directing the greatest air movement on the passengers seated in the car or at the dining car tables.

The breeze thus generated is not the annoying steady gust of air but is intermittent, producing a gentle, cooling draught every three seconds. The velocity of the breeze is controlled under three speeds from a switch located at a convenient point in the car.


New Safety Car Fan, Deflecting Vanes Revolve Slowly, Giving Oscillating Fan Effect

This type of fan is not only a vast improvement in the matter of governing air currents, but performs its task very economically, operating at about 2 amperes when working at maximum speed.

Notwithstanding the merits as already ascribed to this type of fan, it possesses another—and an equally meritorious feature—its adaptability for use in combination with a lighting fixture. This is a welcome improvement to the heretofore crowded car ceiling with alternating fans and lighting fixtures.

Although the Safety Company has undoubtedly been governed largely in its development of this fan by the study of railway car requirements, it is to be expected that a much wider field in its usefulness will develop. We have in mind a number of cases where such a fan could be used to advantage and we predict that it will be generally accepted as a much needed improvement in fan design.

Transportation of Exhibits to Panama Exposition.

The Panama-Pacific International Exposition, through its traffic department, has issued rules and regulations covering the transportation of exhibits to the exposition which will be held in San Francisco from February 20th to Dec. 4th, 1915. Information covering both domestic and foreign shipments is given. In general these provide for full freight rates to the exposition and free return of the shipment if exhibits have not changed hands.

Advertising That Helps You Sell.

"Advertising That Helps You Sell" is the title given to a bound collection of advertisements placed in popular magazines by the Westinghouse Electric & Mfg. Company. The booklet includes advertisements of domestic and industrial applications of electricity which have been placed by this company in the various magazines and is being distributed to central stations and dealers to inform them of the service furnished by this Company.

The House

25 years of specializing in the supply of electrical equipment portant factor in railroad work. Your entire requisition can be covered with one order and you receive the goods *"House of Service"* serve you.

Alexalites

With the extensive application of Mazda lamps in railway service it is very important that all lamps be carefully screened or concealed. The **Alexalite** conceals the light source and insures **safety, comfort** and **economy** in passenger service.

Write for information.

OKONITE

TRADE MARK.

Insulated wire for railway signals, car lighting and power service must be absolutely dependable and have the highest insulating qualities. For years Okonite has been the standard insulation in railroad service. Okonite Insulation contains never less than 30% dry, fine, up-river Para rubber and is made in but **one grade only—THE BEST.**

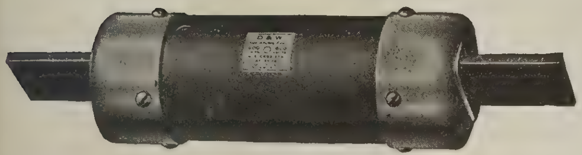
Central Elect

The House

320-326 S. Fifth Ave.

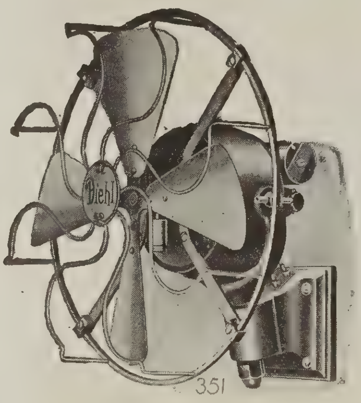
# of Service

for railroads has made "Central Electric Service" an im-
for electrical equipment on any job, no matter how large
in one shipment! Think of the convenience! Let the



D & W Non-Arcing Refillable Fuses

save 65 per cent of your fuse expense—they are refilled at small cost. You can tell a D. & W. Fuse at a glance; it is different; ampere capacity stamped in fibre; safe indicator; no metal exposed; extra heavy caps and tubing and perfect alinement of soldered blades.



Diehl Car Fans

give a finishing touch to passenger comfort. Designed specially to meet the severe conditions of this service. The fan body is readily removed from the base without disturbing the wiring. Pleasing in design.

ric Company

of Service

Chicago

C. W. Harris Goes with Titan Battery Co.

Mr. W. Crighton Harris has resigned from the engineering firm of Crighton Harris & Co. to become chief engineer of the Titan Storage Battery Company, of Newark, N. J.

New Bulletin on Street Car Lighting.

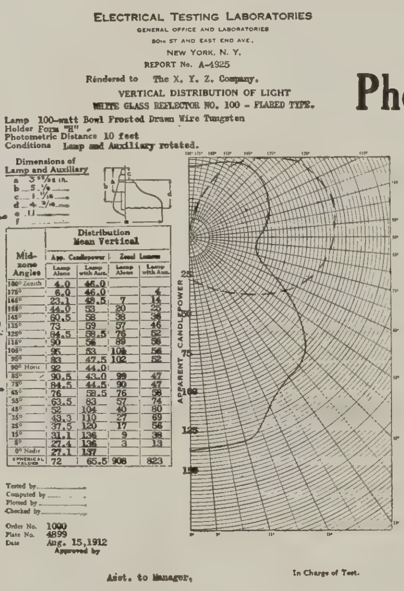
MacBeth Evans Glass Company have recently issued an interesting pamphlet on the illumination of street cars which contains much valuable information in the way of distribution curves, costs, etc. A copy of this booklet will gladly be sent to any of our readers.

A Real Aerial Telephone Line.

The modern telephone trouble man has taken the word "impossible" out of the telephone dictionary for good. A little thing like restoring service after storms and floods offers no serious obstacles, as witness the manner in which service was maintained during a recent storm in California.

A flood in the Salinas River district had washed away pole after pole and the problem of keeping up the wires until the waters should recede presented almost insurmountable difficulties. The familiar box kite provided the solution. The telephone company's men carried a bridle wire across the river by means of a number of large box kites and then used this strand as a messenger for drawing the telephone wires across.

Talking was carried on successfully over this kite line until the recession of the waters permitted the laying of a permanent cable.—*Western Electric News.*


ELECTRICAL TESTING LABORATORIES
GENERAL OFFICE AND LABORATORIES
80TH ST AND EAST END AVE.
NEW YORK, N. Y.
REPORT No. A-4925
Rendered to The X. Y. Z. Company.
VERTICAL DISTRIBUTION OF LIGHT
WHITE GLASS REFLECTOR NO. 100 – FLARED TYPE.

Lamp 100-watt Bowl Frosted Drawn Wire Tungsten
Holder Form "H"
Photometric Distance 10 feet
Conditions Lamp and Auxiliary rotated.

Dimensions of Lamp and Auxiliary

Mid-zone Angles	Distribution Mean Vertical			
	App. Candlepower		Zonal Lumens	
	Lamp Alone	Lamp with Aux.	Lamp Alone	Lamp with Aux.
180° Zenith	4.0	46.0		
175°	6.0	46.0		4
165°	23.1	48.5	7	14
155°	44.0	53	20	25
145°	60.5	58	38	38
135°	73	59	57	46
125°	84.5	58.5	76	52
115°	90	56	89	56
105°	95	53	104	56
95°	83	47.5	102	52
90° Horiz	92	44.0		
85°	90.5	43.0	99	47
75°	84.5	44.5	90	47
65°	76	58.5	76	58
55°	63.5	83	57	74
45°	52	104	40	80
35°	43.3	110	27	69
25°	37.5	120	17	56
15°	31.1	136	9	38
5°	27.4	136	3	13
0° Nadir	27.1	137		
Spherical Values	72	65.5	908	823

Tested by
Computed by
Plotted by
Checked by

Order No. 1000
Plate No. 4899
Date Aug. 15, 1912
Approved by

Asst. to Manager, In Charge of Test.

The Photometric Curve

has become necessary for all illuminating engineering computations.

In order to make our services more valuable, a new photometric sheet has recently been designed for use in tests of this character, which presents not only the polar co-ordinate curve, but also the engineering data which makes the sheet complete for all engineering calculations.

Copies of a specimen report will be sent upon application.

Electrical Testing Laboratories
80th Street and East End Avenue
NEW YORK

Committees
of the Association of Railway Electrical Engineers

Semi-Annual Convention will be held at Atlantic City, Friday, June 12th, Headquarters Hotel Dennis. Annual Convention October 19th to 23rd, at Chicago.

PRESIDENT

C. R. Gilman, C., M. & St. P. Ry.

SENIOR VICE-PRESIDENT

H. C. Meloy, L. S. & M. S. Ry.

JUNIOR VICE-PRESIDENT

E. W. Jansen, Ill. Cent. Ry.

SECRETARY-TREASURER

Jos. A. Andreucetti, C. & N. W. Ry.

EXECUTIVE COMMITTEE

C. J. Causland, Penn. R. R. Lines East.
L. S. Billau, B. & O. R. R.
Wm. A. Del Mar, N. Y. Central.
A. J. Collett, Union Pac. Ry.
N. E. Lemmon, Pullman Co.
J. J. Hack, So. Pac. Co.

COMMITTEE ON AXLE EQUIPMENT.

H. R. Bucks, Chairman, Chief Elec., Oregon Short Line.
Geo. W. Murrey, Chief Elec., S. P. L., A. & S. L. Ry.
E. M. Cutting, Edison Storage Battery Co.
N. E. Lemmon, Elec. Eng., Pullman Co.

COMMITTEE ON DATA AND INFORMATION.

B. F. Bilsland, General Electric Co.
C. J. Causland, Pennsylvania R. R.
George W. Cravens, Cravens Electric Company.
W. A. Del Mar, Asst. Elec. Engr., N. Y. C. Line.
A. J. Farrelly, C. & N. W. Ry. Co.
J. E. Gardner, C. B. & Q. R. R.
W. M. Wiggins, Elec. Insp. Pullman Co
Edward Wray, Chairman, *Railway Electrical Engineer.*

COMMITTEE ON ELECTRIC TRACTION

H. M. Van Gelder, Chairman, Westinghouse, Church Kerr & Co.
J. H. Davis, Elec. Engr., B. & O. R. R.
D. C. Woodbury, N. Y. C. & H. R. R. R.
Paul Real, Ass't Engr., N. Y., N. H. & H. R. R.
Chas. P. Kahler, Elec. Engr., Oregon Short Line R. R.
C. B. Keiser, M. M., Penna. Lines East.

COMMITTEE ON ELECTRIC HEAD LIGHTS.

Chas. R. Sugg, Chairman, Elec. Eng., Atlantic Coast Line R. R.
Geo. E. Murrey, Chief Elec., Chicago Shops, C. & N. W. R. R.
J. J. Hack, Eng. Tr. Ltg., H. & V. Southern Pacific R. R.
Jno. E. Gardner, Elec. Eng., C., B. & Q. R. R.
L. C. Hensel, Chief Elec., St. Louis & San Francisco R. R.

COMMITTEE ON HEAD END EQUIPMENT

K. R. Hare, Chairman, Chief Electrician, N. P. R. R.
Jos. A. Andreucetti, General Foreman, C. & N. W. Ry.
C. R. Gilman, Chief Electrician, C., M. & St. P. Ry.
J. J. Hack, Engineer Train Lighting, Heating and Ventilating, S. P. R. R.

COMMITTEE ON ILLUMINATION

L. S. Billau, Chairman, Elect. Dept., B. & O. R. R.
J. L. Minick, Chief Draftsman, Penna. R. R.
H. C. Meloy, Chief Elect., L. S. & M. S. R. R.
L. Schepmoes, Safety Car Heating & Lighting Co.
D. P. Morrison, Elec. Engr., P. & L. E. R. R.
W. H. Rolinson, Westinghouse Lamp Co.
Preston S. Millar, Electrical Testing Laboratories.
C. W. Bender, National Elec. Lamp Association.

Sub-committee on Lamp Specifications.

J. L. Minick, Chairman,
J. R. Sloan,
Henry Rogers.

COMMITTEE ON INDUSTRIAL TRUCKS.

T. V. Buckwalter, Chairman, Penn. R. R.
C. E. F. Ahlm, Chief Engr. The Elwell-Parker Elec. Co.
H. G. Thompson, Vice-Pres. The Edison Storage Battery Co.
J. E. Hale, Experimental Engr. The Goodyear Tire & Rubber Co.
F. K. Fildes, Elec. Dept. Penn. R. R.
H. A. Currie, Ass't Elec. Engr. N. Y. C. & H. R. R. R.

COMMITTEE ON LOOSE LEAF BINDERS FOR FILING SPECIFICATIONS AND TO KEEP SPECIFICATIONS AND STANDARDS TO DATE

J. R. Sloan, Chairman, Eng. Elec. Tr. Ltg., Penna. R. R.
J. L. Minick, Chief Draftsman, Penna. R. R.
T. V. Buckwalter, Draftsman, Penna. R. R.

COMMITTEE ON OUTSIDE CONSTRUCTION AND YARD LIGHTING

H. M. Warren, Chairman, Elec. Engr., D., L. & W. R. R.
W. H. Keirn, Elect., Penna. R. R.
Jos. A. Andreucetti, Gen'l Fore., C. & N. W. R. R.
C. J. Causland, Chief Elect., Penna. R. R. Lines West.
C. D. Axtell, Gen'l Fore., D., L. & W. R. R.
J. L. Minick, Penna., R. R.

COMMITTEE ON RECIPROCAL RELATIONS

L. S. Billau, Chairman, Elec. Dept., B. & O. R. R.
J. R. Sloan, Eng. Elec. Tr. Ltg., Penna. R. R.
Jos. A. Andreucetti, C. & N. W. R. R.

COMMITTEE ON SHOP PRACTICE

Geo. W. Cravens, Chairman, Manager Welding Apparatus Deparment, C. & C. Elec. & Mfg. Co.
R. F. Moon, Westinghouse Electric & Mfg. Co.
G. M. Crownover, Supt. M. P., Chicago-Great Western Ry.
L. C. Hensel, Chief Elec., St. Louis & San Francisco Ry.

RAILWAY
ELECTRICAL ENGINEER

Official Journal
of the Association of Railway Electrical Engineers.
PUBLISHED MONTHLY BY
WRAY PUBLISHING CO.
EDWARD WRAY,
President.
CARLETON D. SPERRY,
Assoc. Editor.
800 ADVERTISING BLDG.—123 W. MADISON ST.
CHICAGO.
Telephone, Randolph 7414.

Entered as second-class matter, August 6, 1909, at the Post Office at Chicago, Ill, under the Act of March 3, 1879.

TERMS OF SUBSCRIPTION
United States, Canada and Mexico . . . Per Year, $1.00
Foreign .... Per Year, $1.50

CONTENTS

Page
Editorial:
Better Bearings for Car Fans 101
The Annual Convention of the A. R. E. E. 101
New Pullman Battery House 102
Some Notes on Steam Railway Electrification. By J. A. Shaw 106
A. R. E. E. Convention Program 109
Conduit Wiring for Railway Cars 110
Short Circuited Test of a Large Generator 111
New Type of Gas Battery 111
Ore Dock Electric Locomotive 112
Overload Relays 113
Pennsylvania R. R. "School of Electricity"—Lesson No. 15, Mathematics (Continued) 115
The Railroad Electricians' Club:
Lead Storage Battery Questions 121
A. B. C. Car Lighting Course, Lesson No. 32:
U. S. L. System with Ampere Hour Meter Control.. 123
Prize Question Box 126
Practical Stunts 128
With the Manufacturers 130
Association Directory 132

Better Bearings for Car Fans

One of the chief sources of trouble to the terminal electrician at this time of the year is fan bearing failures and trouble from fans throwing oil from flooded bearing. While the former may increase maintenance cost and the terminal electrician's troubles, the latter is very frequently brought to the attention of the railway management in damages for clothes, Pullman carpets, rugs, etc., damaged by oil thrown from the fan.

An easy solution for the whole difficulty would be found in supplying the fans with ball bearings. It seems strange that with such an extensive application of ball bearings to railway car lighting generators, their application to car fans, of which there are fully twice the number in service, should have been given so little consideration by both railroads and fan manufacturers.

The experience with ball bearings in railway car lighting generator service has been, that instead of requiring a daily or bi-weekly inspection, as was the case with generators on plain bearings, these generators equipped with ball bearings are now inspected only once in six months. A six months period of inspection for fans would cover the entire fan season, so that fan bearings would then only require attention once a year, and that would be given when installed. The reduction in maintenance costs, elimination of failure, and avoiding damages, would surely warrant the additional cost of ball bearings for railway car fans.

Annual Convention of the A. R. E. E.

From all appearances the Seventh Annual Convention of the Association of Railway Electrical Engineers, to be held at the LaSalle Hotel, Chicago, October 26-30th, is going to be the most interesting and the most important convention the Association has ever held. The many committees of the Association have been industrially working for months past in preparing their reports, and much of the information compiled will be of direct benefit to not only men in the electrical departments but to motive power officials as well.

The report of the *Committee on Electric Traction,* as outlined at the Semi-Annual Convention of the Association in June, will probably be one of the most comprehensive papers ever prepared on this subject. It will cover past and present developments, a description of the salient points of the various systems used for electric traction, and reasons which determine the practicability of electrification, based on traffic facilities, train movement, etc.

Committee on Data and Information has obtained a very complete analysis of nearly all of the electrical equipment in use by railroads. There are many very interesting facts brought to light by a study of this data, particularly in reference to size of shop motors and the electrical equipment of traveling cranes. The report also gives much detailed data on electrical equipment for car lighting, illumination of shops, stations, yards, etc.

Committee on Head-end Equipment has prepared a very complete report on the construction and the operation of the head-end generator system, in which a 20 k. w. machine is mounted on one of the baggage car trucks, and, being driven by a Morse chain drive from the axle, furnishes light for the entire train.

Committee on Illumination has this year devoted its energies entirely to the subject of yard lighting. Since the advent of the new gas-filled, high efficiency Mazda lamps, it is now possible to seriously consider the matter of effectively illuminating large areas such as classification yards, terminal yards, etc. Whether a large unit system mounted high, or a small unit system mounted low between each pair of trucks, will give the best results, is a subject which the committee is giving careful consideration.

Committee on Industrial Trucks is doing much to standardize certain parts of these trucks, particularly in respect to tires.

Committee on Outside Construction has a valuable report dealing with the details of electrical construction on railroad properties.

Committee on Rules for Car Wiring is preparing a valuable specification which will make it possible for the cars to be wired nearly in accordance with the underwriter's rules.

Committee on Yard Charging Facilities is preparing a valuable report on this subject, comparing the various advantages of the series, multiple, and individual circuit control systems. In view of the present popularity of the constant potential system of charging it will be interesting to see how this system compares both as to cost and operating results with the other two systems extensively used in this service.

New Pullman Battery House

Charging current at the Pullman battery house is supplied by a 75 h. p. motor generator set. The switchboard used for distribution is very compact using carbon piles resistance units. Here lighting equipment is completely overhauled, the tanks and plates are repaired in the battery repair room and the regulators and generators are tested on special racks. The electrolyte is mixed in the acid house where the stills are also located.

The Pullman Company has recently installed a new battery house to take care of storage batteries and other car lighting equipment at their shops at Pullman, Ill. This battery house has several novel features in the compactness, simplicity and flexibility of its switchboard, as well as some new ideas in the manner of handling the electrolyte, which warrant a full detailed description of this installation.

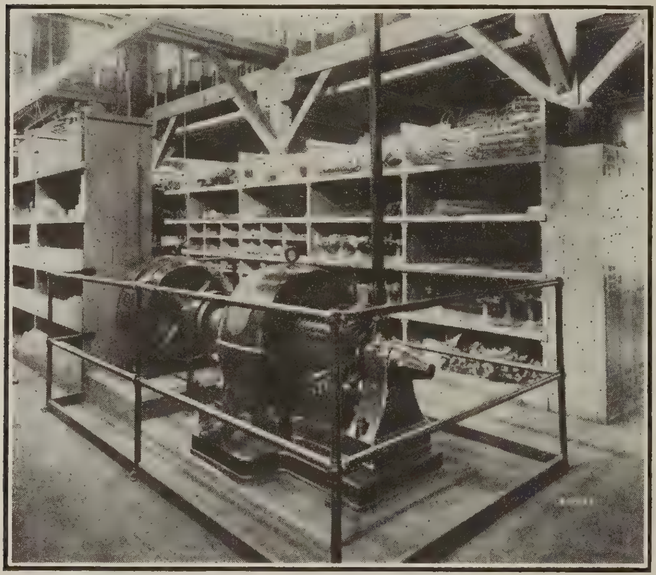


Fig. 1. Motor Generator Set.

The battery house is divided into three departments. In the north end is a general store room where axle generators are repaired, fixtures rewired, and regulators tested and overhauled. Here also is located the motor-generator set for battery charging and the switchboard for power distribution. A solid brick wall with substantial doors separates this room from the two adjacent battery rooms and this serves to keep out all acid fumes which might otherwise corrode the exposed metal parts on the motor-generator set, switchboard and materials in the stock room. The middle department is used for battery cleaning and repairing and in the south section are 98 benches for charging batteries.

Motor-Generator Set.

The power for battery charging is supplied by a motor-generator set, consisting of a 75 h.p., 440 volt, three phase, squirrel cage, induction motor direct connected to a 120 volt, 500 ampere capacity, direct current generator. This set is started by cutting in a resistance into each phase of the power circuit until it gets up to speed. Power is delivered to the bus bars on the switchboard at about 100 volts.

The Switchboard.

The switchboard shown in Fig. 2 and 4 consists of five panels. The main circuit breaker, which is an I. T. E. reverse current type, is mounted on the left hand panel. All connections on the face of the board are made with type "G" Anderson plugs and receptacles. These plugs and receptacles are supplied with a brass guide ring located in front of the contact cylinders; this ring takes all the weight of the plug and cable and relieves the plug and contact from all mechanical strain. The cables vary in length from 3 to

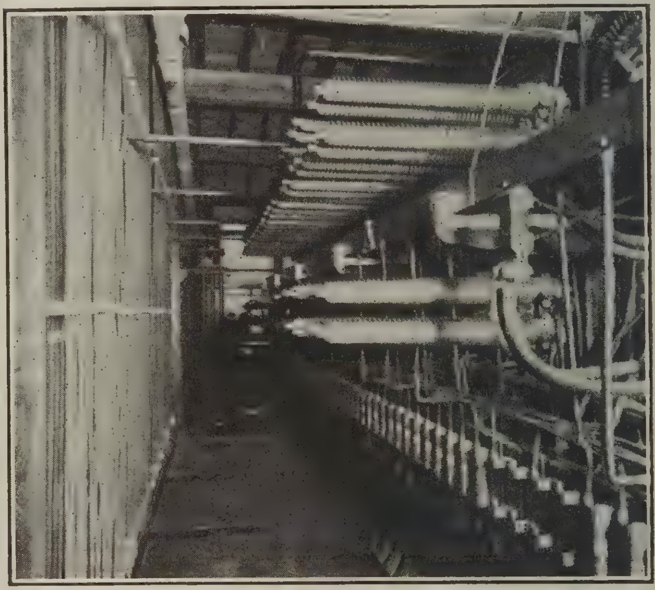


Fig. 2. Back of Switchboard Showing Carbon Pile Resistance Units.

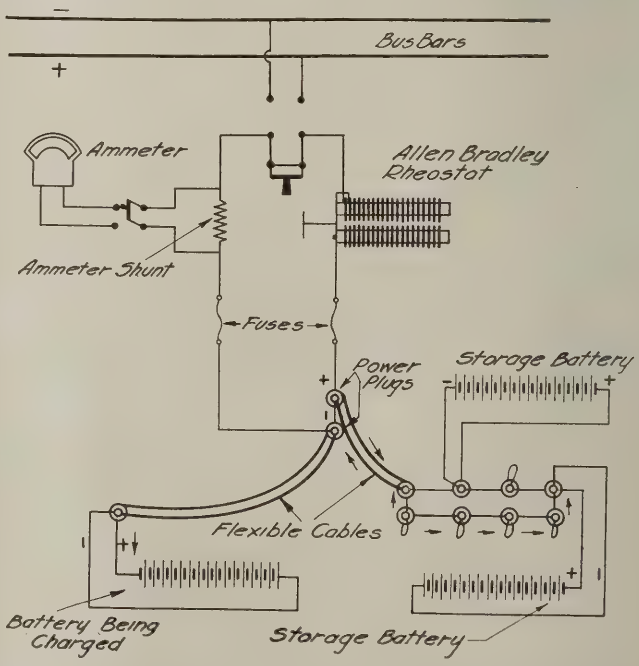


Fig. 3. Diagrammic Sketch of Switchboard Connections.

15 ft. so as to permit of making any desired connections on the board without superfluous cable.

The battery charging terminals of the board consist of 24 pairs of receptacles connected permanently in series; these are the two top rows of receptacles shown in Fig. 4. The three bottom rows of receptacles, numbered from 1 to 98, are connected to similarly numbered battery benches in the charging room.

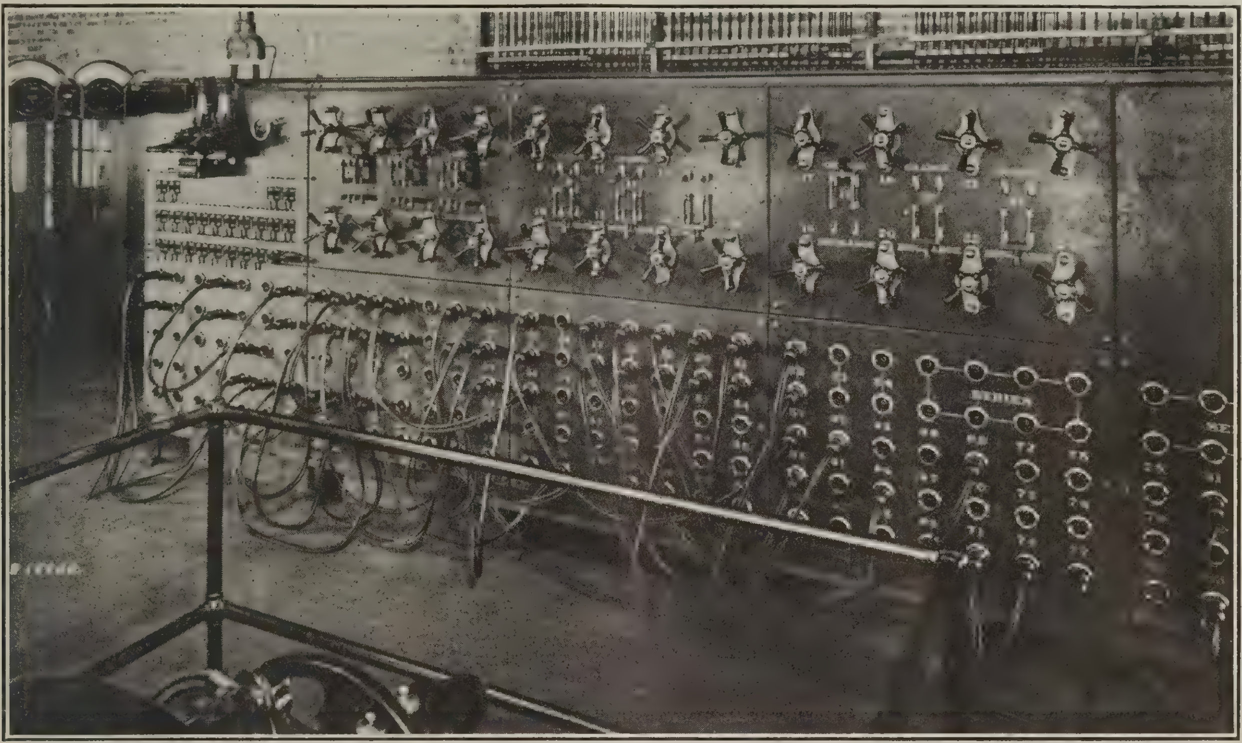


Fig. 4. Front View of Switchboard Showing Arrangement of Receptacles.

On the upper half of the board are shown the adjusting handles for the Allen Bradley type carbon pile resistance. The double throw switches either connect the resistance in series with the bus bars for charging, or short circuit the battery through the resistance for discharging; in either case the resistance is adjusted so that the proper current will flow.

Each resistance unit is made up of four carbon piles connected in series. The separate carbon piles are made up of 1½ in. graphite discs enclosed in insulated metal tubes fitted with fins for radiating the heat. Since the discs are entirely enclosed it is possible to operate the resistance unit at a red heat without seriously oxidizing the discs.

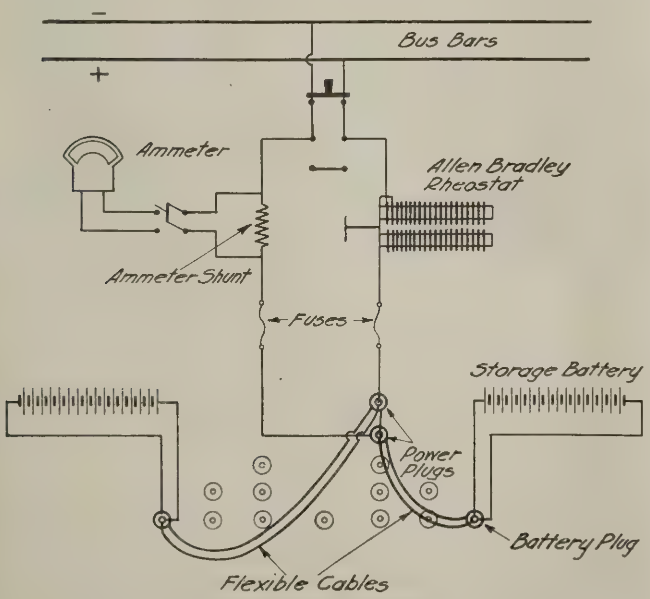


Fig. 5. Connections for Emergency Charging.

The hand adjusting wheels shown on the front of the switchboard operate a screw, which acts through an equalizer to compress or release the pressure on all four of the carbon piles, which decreases or increases the resistance of the unit as desired. These units have a capacity of 3,750 watts and are very compact and sensitive and maybe accurately adjusted to any desired value, making them very desirable for such an installation. Fig. 2 shows the back of the switchboard with tubes containing the discs in place.

Operation of the Board.

The operation of the board is best understood by referring to the diagramatic sketch shown in Fig. 3. For the sake of simplicity, only one set of power receptacles is shown. In charging, the current flows from the positive bus bar, through the adjustable resistance, and a fuse to one power receptacle, back through the other receptacle, fuse, ammeter shunt and to the negative bus bar. If two batteries are to be charged, as shown in the diagram, battery charging receptacles are connected into the power circuit by flexible leads with Anderson plugs on each. Some of these cables are shown in place on the switchboard in Fig. 3. However, if only one battery is to be charged, one of the two series power receptacles is short circuited with a short circuiting plug. This is made up by connecting a short loop directly between positive and negative terminals of the plug.

The ammeter represented in the sketch, Fig. 3, and shown on the bracket at the left of the switchboard, Fig. 4, will indicate the current in any of the battery circuits when the ammeter switch for that circuit is closed. These small ammeter switches, shown in the upper section of the left hand switchboard panel connect directly to the corresponding ammeter shunt in each of the power circuits.

This instrument is virtually a milli ammeter and just a fractional part of the total current passes through it. All shunts in the power circuits are of exactly the same resistance, so in order to have the meter read correctly on all of these shunts, all of the leads to the ammeter must be of the same length in order to make the resistance of all the leads the same.

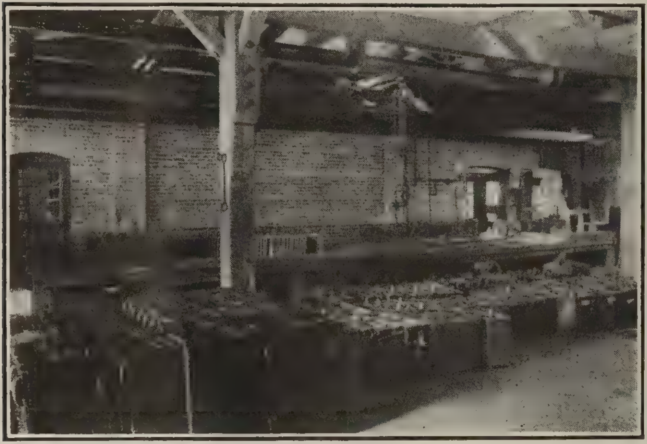


Fig. 6. Battery Repair Room.

Emergency Charging.

It sometimes becomes necessary to charge a certain battery when the usual charging power is not available. For this purpose two sets made up of eight receptacles each, are connected permanently in series, as shown on the right hand side of the switchboard, Fig. 4.

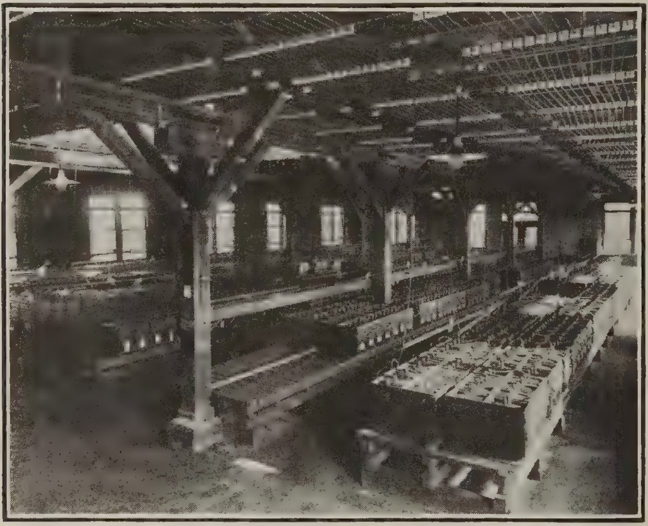


Fig. 7. Battery Charging Room, Note Overhead Wiring.

A battery to be charged is plugged into one of a pair of power receptacles, as shown in Fig. 5. The main switch of that circuit is thrown in the discharge position. The other power receptacle is plugged into the series combination. The two or three batteries used to furnish the charging current are plugged into other receptacles in the series set, and in the rest of the receptacles are inserted, short circuiting plugs. The current flows in the direction shown by the arrows in Fig. 5. The current is adjusted by the rheostat as it was with the power coming from the bus bars.

The Department of Battery Repair.

The department of battery cleaning and repair, is shown in Fig. 6. All batteries are transported in and out of this department on a truck run by storage batteries. The batteries are handled by a chain block suspended from a traveling crane, which runs on an overhead track. Here the connectors are first removed from the incoming batteries; a steam cap is there placed on each truck separately to soften the rubber top of each so that it may be removed without breaking. The steam cap is shown in place on a cell at the right of the illustration. The elements are there removed and the electrolyte either saved or poured into a sewer drain, which empties in a catch basin just outside the building. The twin celled tank is inverted over two water nozzles on the cleaning table and here the sediment in the bottom of the tank is washed out. Each tank is then partially filled with hot water to soften the petrolyte sealing in the lead lining. After this is soft the cell tank is clamped firmly and the lining drawn out by means of a special pair of tongs operated by a chain block on an overhead track shown in the upper right hand corner of Fig. 6.

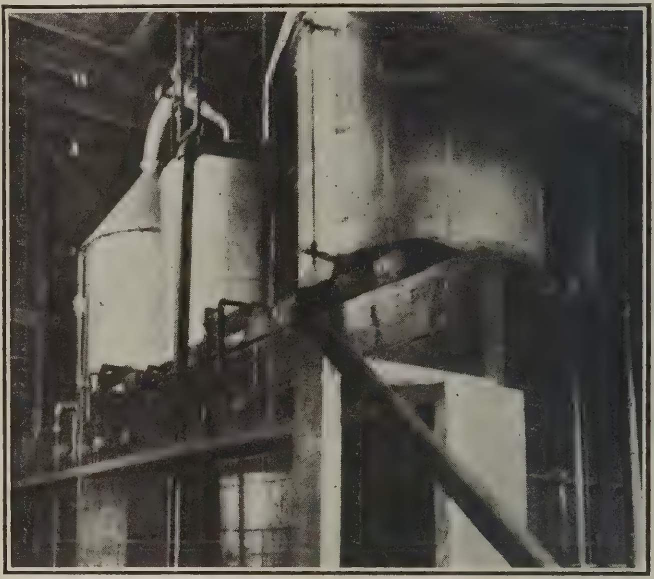


Fig. 8. Stills and Storage Tank.

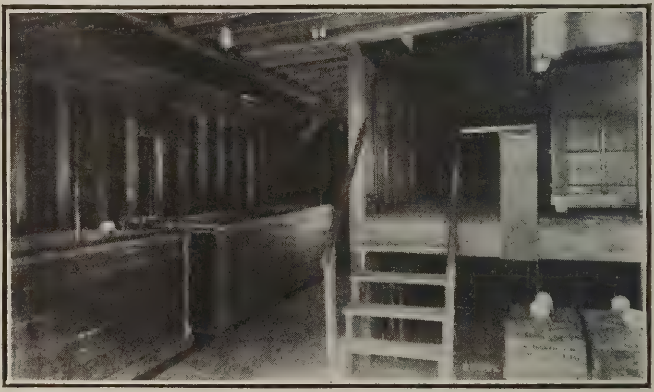


Fig. 9. Acid House, Electrolite Vats on Left Hand Side.

The wooden tanks are immersed for several minutes in a vat containing equal parts of paraffine, rosin and petrolyte, heated to the proper temperature.

This first immersion penetrates the wood thoroughly, and as the tanks are very hot when removed, the petrolyte runs off from the surface. In order to give the tanks a good surface coat, they are first allowed to cool, and then dipped a second time; the cold wood causes a good coating of petrolyte to adhere to the surface.

The lead linings are tested for leaks by clamping on a cover fitted with an air pipe, then immersing them in water and turning on air under five pounds pressure. If there are any holes in the lining the escaping air indicates where the leak is. Leaky tanks are repaired with a lead burning outfit. Before the lead linings are replaced, half a gallon of the melted petrolyte is poured into the wooden tanks to seal the linings in place.

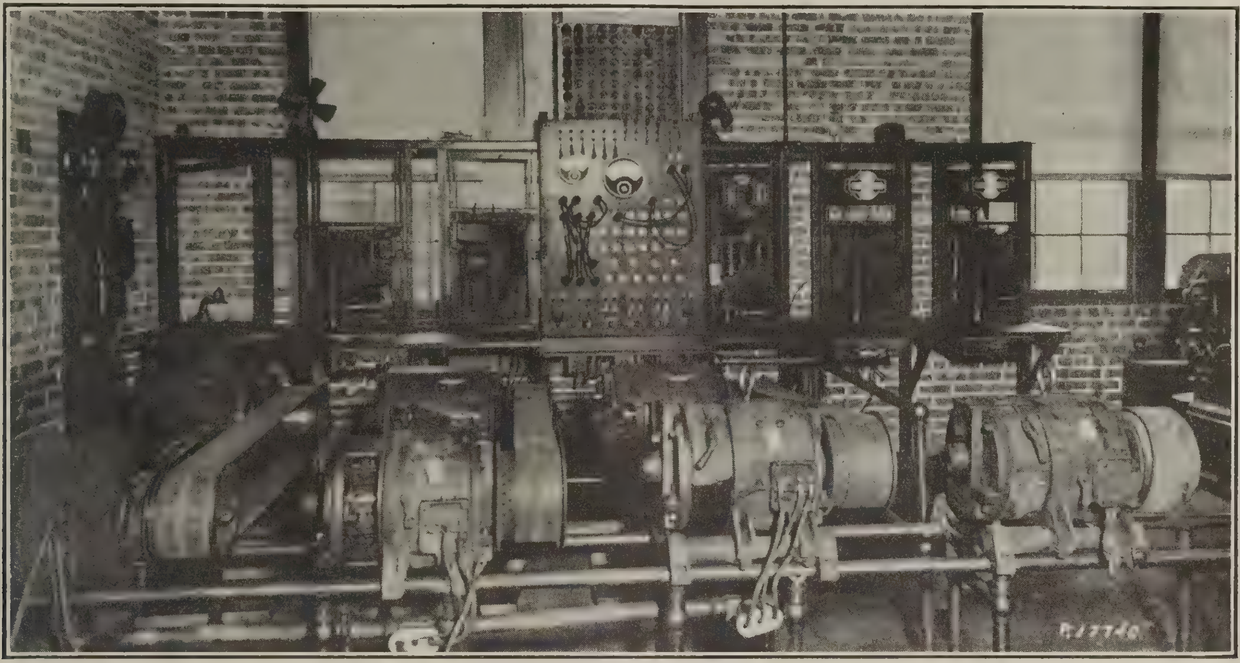


Fig. 10. Test Racks for Generators and Regulators.

The plates, in the meantime, have been straightened and replaced where necessary. The plate presses shown in Fig. 6 are made of old air brake cylinders operating on compressed air. Spacing blocks are placed between plates, as shown, and the whole inserted in the press.

Battery Room.

The battery room shown in Fig. 7, has five rows of battery benches having a capacity for about 100 batteries. The tops of the benches are supported by special glass insulators to prevent grounds. All wiring from switchboard to battery benches is of the openwork cleat construction. Wires run from each bench to similarly numbered receptacles on the switchboard. The battery terminals of each circuit hang from the ceiling as shown and are fastened to spacing rods about the length of each battery section. The terminal connectors, when not in use, are supported up out of the way by hooking the connectors to nails in the wooden rod.

System of Handling Electrolyte.

Over the top of each alternate row of benches runs a lead pipe for supplying electrolyte. From this main feed pipe rubber hose extends so that any battery in the room may be easily filled. A large vulcanite valve is fitted on to the end of each hose. The electrolyte for filling batteries, runs through a lead pipe to the distributing system in the battery room. The tanks of electrolyte in the acid house are about 6 ft. above the battery benches, as this produces free flow, but

with no other metal than lead, as the acid would attack that metal and produce harmful impurities in the electrolyte.

Acid House.

The acid house is located about 30 ft. from the battery house and here distilled water is prepared and the electrolyte mixed.

Fig. 8 shows a view of the two water stills and the condenser between them. The water in the stills is vaporized by means of high pressure steam coils and passes off through the crooks at the top of each still

not under enough pressure to cause leakage; it is very essential that the electrolyte shall come in contact and is condensed in lead pipe coils immersed in water in the condensing chamber. The distilled water then flows into the large wooden storage tank below, this has a capacity of 500 gallons and a water glass indicates the amount of water in the tank.

The electrolyte is mixed in the lead lined vats shown in Fig. 9. Distilled water feeds by gravity from the storage tank through the valves shown between the two vats and acid is dumped in by hand from carboys. The capacity of each tank is 300 gallons and .... carboys of 1.400 acid is used in making up each batch of electrolyte. This is thoroughly mixed by agitating it by means of compressed air emitted from a lead pipe near the bottom of the tank.

Testing Racks.

The car lighting generators and regulators as removed from cars and brought into the shop are placed on the test racks shown in Fig. 10 and thoroughly tested and overhauled. Here all addition of new parts and repairs are made. Generators to be tested are belted to other generators run as motors, the speed of which can be varied so as to duplicate service conditions as nearly as possible. The panels in the background are for mounting regulators as shown.

The switch board enables the operator to cut in lamps as would be done in regular service. Several different makes of regulators are here shown mounted for test.

Some Notes on Steam Railway Electrification

By J. A. Shaw, Canadian Pacific Railway Co.

Mr. Shaw discusses the relative advantages and disadvantages of single phase and direct current as power for electrification of railroads. He shows what factors tend to make it advisable to use one system in preference to another and concludes that in general high tension direct current is to be preferred.

The determination of the preferable system for electrifying a section or branch of a railway, involves that best adapted for general service. If successful, their installation may be extended as electrification of other portions of the road may prove desirable. This will depend on the success obtained in economical and reliable operation. It is necessary in view of further extensions to select a system suitable for general conditions to obtain interchangeability in rolling stock. Possibly different systems may be used on different parts of a road, but each will have to operate under all conditions on the district on which it is installed.

Systems Available.

Three systems now exist which include all which need be considered in view of the present state of electrical development. One, the three-phase alternating, is not suitable for general electrifications, on account of requiring two trolley wires, with the resulting complications and the peculiar characteristics of the motors employed. The remaining two systems are single-phase alternating current, and the 2,400-volt direct current.

The single-phase system has been used in the electrification of the New York, New Haven and Hartford Railway from New York to Stamford, and is now being considerably extended. It has also been used on a number of light railways, notably the Spokane and Inland. Abroad it is in use on the London, Brighton & South Coast Railway, the Swedish State Railway and others, and has been adopted by the German, Swiss and Austrian State Railways as their approved system, although it cannot as yet be considered as completely through the experimental stage.

The 2,400-volt direct current system is a development from the 600-volt system, which is practically the standard in all street railway and interurban work, and which has been so successful on that field. The electrification of the New York Terminals of the New York Central and the Pennsylvania Railroads, the Atlantic City Line of the Pennsylvania, the New York Subway, and all elevated railways have also employed this system. Abroad it has been used on the Lancashire & Yorkshire Railway and in general under conditions similar to those in this country. During the past three years a number of light railways have been installed using 1,200-volt direct current, in most cases, however, using 600-volt motors, and from the experience obtained the 2400-volt system has been developed using 1,200-volt motors, and this system has now been in use on the Butte, Anaconda & Pacific Railway, preparatory to a further use of it on two divisions of the Chicago, Milwaukee & Puget Sound Railway, for the past 10 months. A lower voltage installation at 1,500 volts has been in service over three years on the Piedmont Railway in South Carolina.

Supply of Power.

It is possible that in the majority of cases for years to come that power will be generated for locomotive purposes alone, without considering its use for other purposes. However, electrification will be made possible more through cheap power being available from existing power plants, where if a separate plant had to be erected it would be too expensive. Possibly in the future power plants will be constructed at points where commercial power is not available, but even in that case at other points on adjoining divisions commercial power might be obtained, and to permit of uniform equipment the power generated would either have to be uniform with that purchased or the latter converted to the character required. Throughout the West and in the Montreal district, 60-cycle, three-phase transmission is practically universal, and while 25-cycle, three-phase current is employed on the Hydro-Electric and Toronto-Niagara transmissions from which 25-cycle single-phase could be obtained by stationary transformers, balancing apparatus would be required. In view of the tendency to use 15-cycle in place of 25-cycle current in single-phase electrification and the remoteness of general electrification in Ontario, it is reasonably safe to assume that converting apparatus will be required for either single-phase or direct-current installation. The application of 15-cycle generators in 60-cycle power stations or of frequency changing apparatus to furnish single-phase current, while possible, does not actually change this assumption, as the increased price asked for by the power companies equals the cost of conversion by the railroad in addition to requiring the erection of separate transmission lines.

General Arrangement.

The general arrangement of the two systems may be outlined as follows:

Single Phase.

A 1. Power line of supply company.

A 2. Conversion station at one or two points per division furnishing single-phase current from motor-generator apparatus and step-up transformer for raising potential.

If power lines are available at several points on division, number of conversion stations may be increased, and length of transmission lines correspondingly reduced.

A 3. Transformer line from conversion stations to transformer stations.

A 4. Transformer station in which high voltage single-phase current is transformed to 11,000 volts for trolley line.

A 5. Trolley line and bonding.

A 6. Electric locomotives or motor cars.

Direct Current

D 1. Power line of supply company.

D 2. Transmission line to sub-stations. Where supply company power lines are available at several points on division, sub-stations may be conveniently located at such points, and length of transmission line correspondingly reduced.

D 3. Sub-stations in which three-phase power is converted to direct current by motor generator apparatus.

D. 4. Feeder line to which direct current is supplied to trolley line.

D 5. Trolley line and bonding.

D 6. Electric locomotives or motor cars.

Cost of Installation.

An inspection of above table shows that as a general proposition certain of the items are practically common to both systems. Transmission lines A-3 and D-2 will be required for the entire length of the division if power were received at one point; whereas if power were received at several points, while several single-phase conversion stations could be installed, that would not prove practically economical, and with direct current there would be a saving in the transmission line required. The transmission line for single-phase current costs 20 per cent more per mile than that for three-phase, so that it is entirely fair to the single-phase to consider the cost of transmission lines equal.

The trolley line and bonding are practically the same. For single-phase, higher insulation is required on account of the higher voltage and the surging which occurs. With the improvements that have been made in the manufacture of insulators, the difference would not exceed 10 per cent of the cost of the trolley line.

The conversion stations and transformer stations A-2 and A-4 for single-phase, will correspond to the sub-stations D-3 for direct current. For heavy traction work on the Chicago, Milwaukee & St. Paul Railway, where it is proposed to handle 1,600 tons on 1 per cent grades, the sub-stations will be located from 18 to 24 miles apart, the feeder being 1,000,000 cm. Considering a direct current section having sub-stations 20 miles apart the distance between transformer stations for single-phase current will depend on the worst conditions that should be permitted to occur. Thus with the direct current with a voltage drop of 50 per cent, trains could be handled at one-half speed with full tractive power. With single-phase the maximum drop permitting this condition would be from 20 to 30 per cent. The latter figure will be taken as most favorable to single-phase, and the distance apart of stations calculated: 1st, when the number of trains on a section is proportional to its length; 2nd, when the same number of trains are concentrated at the center of a section irrespective of its length. The spacing of the stations can also be calculated when the efficiency is the same for both systems, the number of trains per mile of track being the same. The results are as follows:

Limiting operating conditions, trains uniformly distributed or number proportioned to length of section	30 miles
Limiting operating conditions, same number of trains at center of section	45 miles
Equal efficiency, number of trains proportioned to length of section	30 miles

The limiting operating condition with the number of trains proportioned to the length of the section is evidently most important from a general railroad standpoint, and transformer stations, say 33 1-3 miles apart, would apparently give substantially equal service compared with direct-current sub-stations 20 miles apart. The total capacity of the direct-current sub-station will exceed that required in the conversion station, since each sub-station must be able to carry the load of the trains that may be starting in its vicinity. The total cost of the single-phase stations is, however, increased by that of the transformer stations, which cost one-third as much per kilowatt capacity as the conversion or sub-stations. The two systems are thus equal in cost when the sub-station capacity with direct current is 44 per cent greater than the conversion station for single-phase. In some cases the difference is not sufficient, but lines will not be electrified on which traffic is insufficient to render the load reasonably uniform. As in the case of the transmission line and trolley the single-phase was more expensive; in this case the direct current will be in general slightly higher—the net results being very closely the same.

The remaining items are: A-6 the single-phase locomotives, D-4 the direct-current feeder, and D-6 the direct-current locomotives. The feeder proposed is of 788,000 cm. area, costing at 18 cents per pound, $2,250 per mile or $2,500 per mile erected. The cost of the locomotives will vary according to the type and capacity but based on direct-current locomotives, costing $40,000, those for single-phase current will cost $60,000, so that if one locomotive is used for each eight miles of track, the total cost of the two items is again substantially equal.

The net result is that where power is obtained from three-phase distribution, the cost of electrification by single-phase or direct-current is substantially the same. This is confirmed by several careful independent estimates. With direct current the expenditure on feeder copper and sub-station apparatus is balanced by the slightly increased cost of the trolley and transmission line for single-phase current and the much greater cost of the locomotives.

Cost of Operation.

Cost of operation is affected by the efficiency of the system, the cost of operation of the sub-stations and the cost of the maintenance of the locomotives and other apparatus.

The efficiency of the system will determine the cost of the power supplied, and, if the movement of the trains and the power they each consume is known, could be calculated with considerable accuracy. When power is purchased, especially water power, the cost depends on the peak load during certain hours, and trains will be operated to reduce this as much as possible. It is therefore difficult to forecast the train distribution. There is, however, no general evidence to show that greater efficiency may be obtained with single-phase than with direct-current equipment. Several records of actual service show that with direct-current under similar conditions the results are more economical than single-phase. This is especially so when the power per car mile is considered on account of the greater weight of the single-phase equipment. From what we have already learned and figures published, it may be safely assumed that on any section of a railway on which there is sufficient traffice to justify electrification, the power required by direct current will not exceed that required by single-phase.

The cost of sub-station maintenance and operation is greater for direct current. On a 100-mile division there would probably be five (5) sub-stations, each containing moving apparatus which requires attention as against one for single-phase system. Each of these sub-stations would cost from $3,000 to $4,000 per year, or say $18,000 per annum, against $4,000 for the single-phase station. It is doubtful whether the wages cost of $2,000 per year per station, or $10,000, is a proper charge against the direct current. On main line work it will be absolutely necessary to arrange to cut out any portion of the road on which accidents may occur, and for this purpose attendance will be required. Trains must be moved away from any section temporarily disabled to prevent congestion, and of the $14,000 additional cost it would appear entirely fair to estimate that about $8,000 is the most that would be entailed by the sub-stations. This is more than equalized by the greater cost of maintenance of the single-phase locomotive. Direct-current locomotives are being maintained for 3¼ cents per mile, of which 2 cents is entirely separate from the electric motor, control, etc. On the single-phase locomotives, the cost has been higher, but it is hoped to reduce it to between 5 and 6 cents. For short distances the direct-current locomotives as used out of New York will handle a train that requires two single-phase, and if this were allowed for, the difference would be very great. The new switching and freight locomotives on the New Haven, it is stated, have been maintained for a comparatively low figure, but they have as yet not been in service sufficiently long to give a final value. The construction of all single-phase locomotives is far less sturdy than that of direct current, on account of the difficulty of keeping the weight down to a reasonable amount, and the construction is far more complicated. It cannot be expected, therefore, that they can be maintained for a lower percentage of their total cost. A fair difference to assume is that cost cannot be taken at less than 2 cents per mile for locomotives of equal power, say 1,000 h.p. each. Considering a division with 1,000,000 miles per year, or $20,000 at this figure, so that the cost of operation and maintenance of sub-stations is more than taken care of by the increased cost of maintenance of equipment. The single-phase locomotive is also considerably heavier than the direct-current for equal power and this is especially true when motor car equipment is considered. This increase in weight means a correspondingly reduced train load, unimportant on level districts, but of appreciable amount on heavy grades. It also entails an additional expense for power, which is serious in light passenger or motor car service. There is, of course, a possibility that 2,400-volt direct-current apparatus will cost more to maintain than 600 or 1,200-volt, but there does not appear to be any reason to fear its becoming excessive. While there is no doubt that the New Haven have had more electrical trouble than the New York Central and the cost of repairs has been higher due to the mechanical construction of the locomotives rather than to the electrical equipment. This mechanical construction is, however, necessitated by the use of the single-phase motor. There is no reason why the same construction should not be employed with the 2,400-volt direct-current system as with the 600-volt. In general, there is no reason to expect the cost of operation with the single-phase system to be less than that with the direct current.

Telegraph Interference.

One of the objections to the use of single-phase current is its effect on telegraph and telephone wires. It is stated that this may be overcome by the use of suitable apparatus or by moving the wires to about 200 feet from the power lines. It is questionable whether either of these modifications will entirely eliminate the difficulty, and it is certainly an objectionable feature. With direct current the corresponding difficulty arises from electrolysis, but this is far less important in railway than in street railway work, in which it has been largely overcome.

Possible Difficulties With 2,400 Volts.

The above discussion considers that 2,400-volt direct current will prove equally satisfactory as 600 or 1,200-volt installations. In a system that has not been thoroughly demonstrated in practical service, there are some features from which trouble may be experienced, and these are discussed as follows:

The simple and strong design of the direct-current locomotive is partly due to the use of geared locomotives for freight service and gearless for passenger service. The construction which has been adopted and which is practically necessary for single-phase locomotives of any sizes, supports the motor entirely independent of the wheels, the latter being driven through springs or connecting rods, thus reducing the dead weight to that of the wheels and axles alone, while retaining the same total weight on each wheel. The center of gravity of the locomotive is also raised to a point approximating that general for steam locomotives. From experiments conducted on engine and tender trucks and the experience of maintaining track under various types of locomotives, it is safe to assume that the dead weight of 9,000 to 10,000 pounds per axle on gearless locomotives and the slightely greater weight on geared, does not, for the services in which they will be respectively used, appear likely to affect the cost of track maintenance sufficiently to justify the additional expense and complication involved in reducing it. In view of the greater total weight of the single-phase locomotive it is very doubtful whether its effect on the track will not be greater than the direct-current locomotives, even though the dead weight per axle is higher in the latter. Increasing the height of the center of gravity reduces the lateral shocks on the rail, but this action is caused by these shocks in steam locomotive design being absorbed by the vertical movement of the springs. It will be unfortunate if electric locomotive design cannot be developed in which these shocks are absorbed by springs, or frictional methods of restraint, so that the simplicity which should accompany the application of motors to drive the wheels of a locomotive may be retained; there is no reason to doubt this being accomplished. Should it prove impossible, the direct-current locomotives would become more complicated and approach the single-phase more closely in cost, the difference being probably 25 per cent in place of 50 per cent.

The question of current collection at 2,400 volts at high speed has been experimented with, but not fully demonstrated as yet in service. It has been found practical to collect 200 amperes at 60 miles per hour from one roller trolley without injurious sparking, which at 2,400 volts equals 480 kw. Two trolleys can be located 20 feet apart, thus permitting 960 kw. on one locomotive. This question is important, but there seems little question of its being solved satisfactorily. The control of 2,400-volt current does not appear to present any difficulty. Contactors will be arranged to break the current in series, and from results in operation there seems no reason to anticipate any more trouble with 2,400 volts than with 600. Maintenance of motors may be higher with 2,400 volts than with 600 volts. The motors will, however, operate under 1,200 volts each, and the fields in both motors will practically be at ground potential. Twelve hundred volt motors have operated interurban work for five years without indicating any increased cost of maintenance and while this has been in a dry climate, the forced ventilation to be employed in railway work will give very closely the same condition. The 2,400-volt motor will have the same capacity to stand heavy starting load, the same freedom from commutation trouble, and in general the same ability to stand the severe service imposed upon it by locomotive or traction work that the 600-volt motor has been proved to possess.

The operation of fan and compressor motors on high voltage has to be properly worked out. There are no doubt some difficulties in this respect, but they should certainly be overcome by experience.

Comparison of Systems.

It has been shown that on the assumption that the 2,400-direct current and the 11,000-volt single-phase current system each operate as satisfactorily as their advocates claim, that there is comparatively little difference in their cost of installation and operation. Each is equally flexible, each will operate and in all probability give a high degree of satisfaction compared to steam locomotives. The principal difference is that, with the direct current, a larger portion of the cost of installation is in feeder copper and conversion apparatus, and less in the locomotives, and a larger portion of the cost of operation is in the sub-stations, attendance and maintenance in place of locomotive maintenance. This of itself should prove decidedly to the advantage of the direct-current system, as the sub-station apparatus is stationary and can be carefully maintained, and the simpler and cheaper the locomotive the less danger there will be of breakdown. In addition, the investment in copper is permanent, while that in locomotives may rapidly depreciate with any new developments. There are, in addition, some minor points worth attention which may be referred to.

The regulation of speed on the single-phase system is in many ways preferable to that on the direct current. By drawing current from the transformer at the voltage suitable to the speed and power required, all speeds are equally efficient, and the use of resistance in the circuit is avoided. This is an exceedingly ingenious method, but it is doubtful whether it is of great practical importance. While the direct-current motors have only two full-power efficient speeds, decreased power can be obtained at higher speeds than either of them by field control with very small loss in efficiency. This would apply particularly in passenger service, since in freight service the characteristics of the motor are such that it would not be required. The use of a transformer on the single-phase locomotive permits the operation of the motors at low voltages, and on ungrounded circuits. There seems, however, no reason to fear the use of high voltage on the direct-current motors, or danger, providing it is properly insulated. There has certainly been more trouble on the single-phase from grounds than on the direct current, and it appears to be entirely a question of proper insulation. The relation between the speed of the motor and the power it will develop is different for single-phase and direct current. Taking two motors which will develop the same power at a given speed, the direct current will develop greater power at lower speeds and less power at higher speeds than the single-phase motor. This is the reason for the success of the direct-current motor in traction service. It can exert a greater pull without injury and is less liable to damage from overheating when starting a heavy load than any other type of motor. It is also this feature which makes the gearless locomotive a possibility for passenger service, as it enables a motor of reasonable size to start a passenger train without the use of gearing to furnish the necessary power. Direct-current motors can certainly be constructed to handle passenger trains at high speed if desired, so that in this respect the advantage is greatly in its favor. The direct-current motor has obtained its reputation for ruggedness from its capacity to withstand heavy loading without injury.

Conclusion.

If in place of discussion the relative advantage of single-phase and direct-current traction, the start is made from the direct-current system with its simple and strong electrical apparatus developed after years of experience by simply an increase of voltage, and assuming that this increase does not lead to unforeseen difficulties, the question becomes, What is gained by the use of single-phase current?

It does not save in cost of installation or operation.

Its application is not more flexible.

It introduces a locomotive that is more complicated, in which the motor is necessarily far more expensive and elaborately constructed, and which weighs considerably more than one for direct current.

It reduces cost of sub-station attendance at the expense of locomotive maintenance, and consequent reduction in reliability.

The general advantages to be gained by electrification are too well known to bear repetition, but it might be mentioned from the data now becoming available from those installations now in operation that results obtained confirm estimates very closely. The engineers of the Chicago, Milwaukee & St. Paul Railway estimate that at least a saving of 25 per cent will be made in operating costs on the 440-mile division now to be electrified in the Western states, and part of this saving is confirmed by the showing already on the Butte, Anaconda & Pacific Railway, where power cost has been found to be but one-third of the previous coal cost. The decision to electrify the suburban lines of the Pennsylvania Railway about Philadelphia was made to relieve the existing congestion by increasing the capacity of terminal 15 to 20 per cent, or sufficient to relieve the situation for the next five or six years, and at less expense than any other method.

A. R. E. E. Convention Program

The annual convention of the Association of Railway Electrical Engineers will be held at the Hotel La Salle, Chicago, Oct. 26-30. Many important committee reports will be presented as outlined in the following program:

Tuesday, Oct. 27.

Morning Session—10:00 a. m.
  Address of president.
  Report of secretary-treasurer.
  Unfinished business. New business.
Afternoon Session—2:00 p. m.
  Report of Committee on Loose Leaf Binders for Filing Specifications and to Keep Specifications and Standards to Date.
  Report of Committee on Reciprocal Relations.
  Report of Committee on Specifications for Wire Crossings for Potentials Above 100 Volts.

Wednesday, Oct. 28.

Morning Session—9:00 a. m.
  Report of Committee on Data and Information.
  Report of Committee on Standards.
  Report of Committee on Electric Headlights.
Afternoon Session—2:00 p. m.
  Report of Committee on Industrial Trucks.
  Report of Committee on Electric Traction.
  Report of Committee on Wire Specifications.

Thursday, Oct. 29.

Morning Session—9:00 a. m.
  Report of Committee on Axle Equipment.
  Report of Committee on Head End Equipment.

Report of Committee on Standard Rules for Car Wiring.

Afternoon Session—2:00 p. m.

Report of Committee on Outside Construction and Yard Lighting.

Report of Committee on Illumination.

Report of Committee on Shop Practice.

Friday, Oct. 30.

Morning Session—9:00 a. m.

Report of Committee on Yard Facilities for Charging Storage Batteries.

Report of Auditing Committee.

Election of Officers.

There will be an informal reception and opening dance in the East Room of the hotel Monday evening, October 26th. A matinee theatre party for the ladies will be given Wednesday afternoon, and in place of the annual banquet the committee has this year provided for an informal dinner dance, which will be virtually the same as the banquet of previous years, except for the formality of speakers.

Conduit Wiring for Railway Cars

The present state of the art of lighting steam railroad cars by electricity reflects great credit upon those who have been concerned in the design and manufacture of the apparatus. The severe requirements imposed by the conditions encountered are appreciated only by those who are acquainted with the elementary principles of electrical apparatus.

The traveling public expects good lighting and accepts it largely as a matter of course, making no comment except in case of failure. Car lighting apparatus as now manufactured is of such a high degree of excellence that a failure from defective material or poor design is rare.

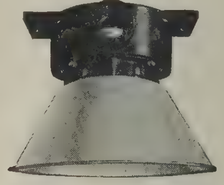
Manufacturers of this material have done all within their power to insure reliability of service and low maintenance cost. Nevertheless the solution of the problem of continuity of service and efficiency of operation is not all in the hands of the manufacturer of the apparatus. That the apparatus be correctly installed and protected is as important as the correctness of design, workmanship and materials. A system equipped with the best apparatus procurable is unreliable and costly to maintain if the distribution system is faulty. The purpose of this article is to emphasize the importance of carefully considering the wiring system, its installation, protection and ease of repair.

Car wiring has passed through about the same stages of development as the wiring of buildings; cleat, knob and tube construction first, then wooden moulding—the moulding giving away to iron conduit. As in the case of buildings the use of iron conduit has proven to be the best method of distributing and protecting electric wires. It is almost unnecessary to point out the entire unsuitability of cleat construction for car wiring. Such a system is unreliable, dangerous and costly to maintain. One has but to observe the roof or underside of a car on a snowy or rainy day to appreciate that it is folly to expose electric wires to such conditions. Furthermore, cleat and knob and tube construction are not suitable for the interior of a car. The extreme vibrations to which a car is subjected soon loosens the wires from their supports, allowing them to come in contact with the car structure. The insulation is quickly abraided and a failure, and possibly a fire, results. In either case the interior finish must be removed so as to replace the damaged wires—an expensive operation requiring the shipping of the car.

Wooden moulding provides but slight protection for the interior wiring and is absolutely worthless when installed upon the roof or underside of a car. It is extremely short lived and cannot be kept tightly closed, thereby allowing cinders and dust to accumulate around the wires which soon destroys their insulation. As wooden moulding has been found unsuitable for use in the wiring of buildings, it is hardly to be wondered at that this system has also proven unsatisfactory for the wiring of cars, where the conditions are much more severe.

The railway electrical engineer has found that rigid iron conduit best meets the peculiar and exacting requirements of car wiring. It provides mechanical protection for the wires which is as enduring as the car. If properly installed it protects the insulation from the deteriorating effects of cinders, dust and moisture. In case of a short circuit the fire hazard is reduced. But little space is occupied. It can be readily bent to conform to the shape of the car structure. A continuous wire-way is provided from outlet to outlet through which new wires can be drawn, if required, without disturbing the inside finish or making it necessary to shop the car. This latter advantage facilitates quick repairs, an item of importance particularly appreciated by railroad men.

Axle Generator Disconnecting Condulet.


Typical Fixture Condulet.

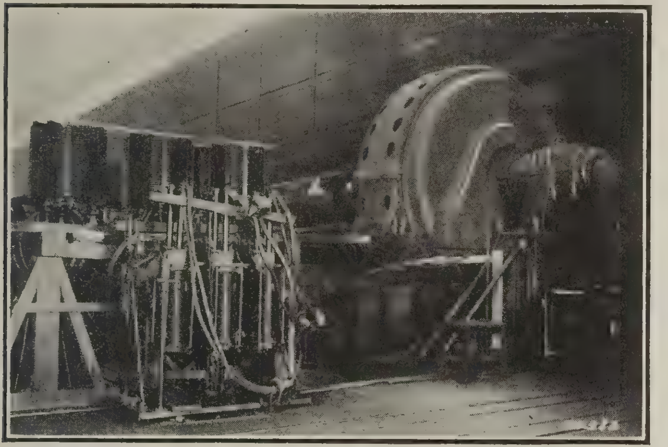
To obtain the full benefit of a conduit system there are two important points to which careful attention should be given: First, the system should be continuous; that is, there should be no breaks which would render it impossible to fish new wires through. Second, the system should be made up tight to prevent the entance of dust and moisture. Care should also be used to see that the conduit is securely fastened in place to prevent rattling.

One of the chief reasons why railway electrical engineers have been reluctant in the past to use rigid iron conduit for car wiring has been the absence of suitable conduit fittings. The ordinary outlet boxes, such as used in the wiring of buildings, with their accompanying lock nuts and bushings, have proven entirely unsatisfactory for car wiring as they soon work loose and fall off. Now, however, the engineer finds upon the market a complete line of conduit fittings which meet every car wiring requirement.

One other reason which has hindered the use of conduit in railway cars has been the lack of wiring space. Happily this condition is being rapidly overcome as the railway electrical engineer is clearly emphasizing to his superiors the necessity of giving as much attention to the conduit system as to the air and steam piping arrangements.

Short Circuited Test of a Large Generator

In the presence of a number of representatives of central stations, a series of tests were conducted recently by Westinghouse engineers in which a 16,700 kva., 8,800 volt generator, running at full speed and without resistance or any other protection in the circuit was deliberately short circuited. Oscillogram records showed that a current of 21,000 amperes, or 12½ times normal, flowed through the generator.



Generator Set Up for Short Circuiting Test.

With generators designed some years ago such a test would have wrecked the machine but in the present instance no damage whatsoever was done. The only visible effect was a static flash between the field and the armature.

The test was performed to prove the fact that generators are being built that require no outside protection from outside short circuits, the generator itself being so designed as to be self-protecting. Unless the generator is properly constructed a complete short circuit tears out the armature coils, which, coming into contact with the revolving field, causes extensive wreckage. Furthermore, the static flash, which always occurs under such circumstances, will destroy inferior insulation. With generators of the type tested, however, both results are guarded against by firmly securing the armature coils and bracing their ends, on one hand, and by the use of mica insulation on the other. In consequence even so severe an ordeal as this test was withstood without harm, although it has been repeated many times with the same machine.

In connection with this test several others were carried out in order to prove the reliability of circuit-breakers and reactance coils for protecting the feeder circuits. The generator was repeatedly short-circuited through these devices which stood up admirably under the enormous stresses to which they were subjected.

The practice recommended by the Westinghouse engineers is to protect the feeders and not the generators. If the generators are protected and a short circuit occurs on any of the feeders, even a poorly designed generator will not suffer, but the voltage will fall on all feeders, all synchronous motors will be thrown out of step, and an overwhelming overload will be thrown on the circuit-breaker of the short-circuited feeder, since it will carry the total current of all the generators in the station. If, however, protective reactances are placed in each feeder circuit, and a short circuit in a feeder occurs, only that feeder will be affected and even then its reactance coil will prevent the current in it from rising to too high a value. The voltage will be maintained at the buss bars and no disturbances will be felt in the remaining feeders. This happens, of course, provided that the generators are self-protective; if not, such an event may seriously injure them.

It is of course possible to protect non-self-protecting generators by reactances, but as the test described above shows, such a proceeding is unnecessary since generators can be supplied that are immune to the worst conditions of load that can be imposed upon them.

New Type of Gas Battery

Dr. Karl Siegl*

Gas batteries are by no means of recent invention, for as early as 1838 a scientist by the name of Matteucci discovered that there is a difference of potential between two platinum electrodes if they are immersed in different gases and a year later Grove constructed his well-known gas battery.

This consisted of 2 platinum electrodes, both covered with black spongy platinum, and the lower ends of the plates dipped in dilute sulphuric acid. Glass jars are placed over each of these plates and these are filled, one with oxygen and the other with hydrogen. If the electrodes are then connected by a platinum wire through the glass cover to a delicate galvanometer, it is found that current flows in the external circuit from the oxygen to the hydrogen. It was later found that gases have a certain definite arrangement as to single potentials very much the same as that given for the various metals on page 103 of our August 1913 issue; this list of gases arrange themselves in a certain definite order, beginning with chlorine and ending with hydrogen.

It was found that oxygen would not attack a carbon electrode, but that chlorine would. The carbon breaks up into powder and carbon dioxide and carbon monoxide are generated, and the surface of the carbon block turns a dark blue color. There have been numerous theories advanced explaining the action which occurs.

After repeated experiments by the author, an electrode was designed which seems to eliminate the quick polarizing difficulty of the earlier gas batteries. Small pieces of carbon about ⅛-inch in size are coated with an even layer of platinum black. These carbon lumps are placed in flat jars of unglazed earthenware, which forms the gas chambers and which also contain carbon plates acting as contact terminals. The earthenware jars are soaked with an electrolyte, usually of dilute sulphuric acid, and this serves to moisten the carbon surfaces, bringing them into contact with the gases. By having the carbon in granulated form a large surface is exposed to gas action. Platinized carbon particles are placed in each jar, the author states that various gases have been tried, chlorine, oxygen, air, carbon, dioxide, acetylene, coal gas and hydrogen. Dilute sulphuric acid was used as the electrolyte in all cases except where chlorine has been used; in which case, dilute hydrochloric acid was employed as electrolyte.

The cells may be connected in parallel or series the same as any other storage or primary battery, and accordingly, any current or voltage within small limits may be obtained.

---

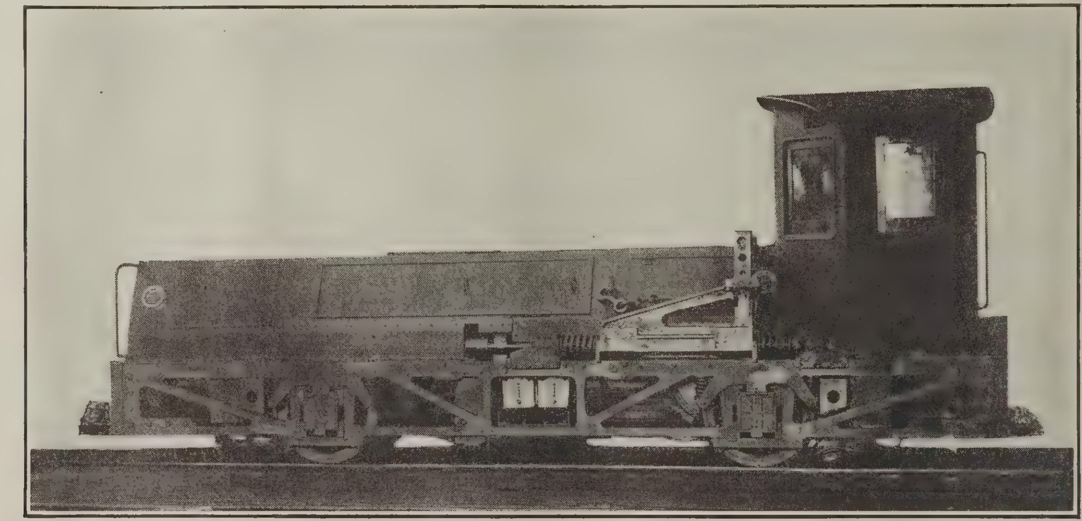
*Abstract of an article in the "Elecktrotechnische Zeitschrift."

The author gives the following data on various types of cells: with chlorine and hydrogen the voltage was 1.4 volts and the cost per kilowatt hour was 10½c; with oxygen and hydrogen, the voltage was .9 volts, and the cost per kilowatt hour 8½c; with air and hydrogen, the voltage was .8 volts and cost, per kilowatt hour, 5c; with air and coal, the voltage was .7 volts, and the cost per kilowatt hour 4c; with carbon dioxide and hydrogen, the voltage was .8 volts, and with air and acetylene, the voltage was 0.3 volts per cell.

The maximum current for a momentary discharge with the author's cell is about 25 milliamperes per square inch of active surface. After continuous discharge the gas battery will give slightly less than 2 milliamperes per square inch of active surface.

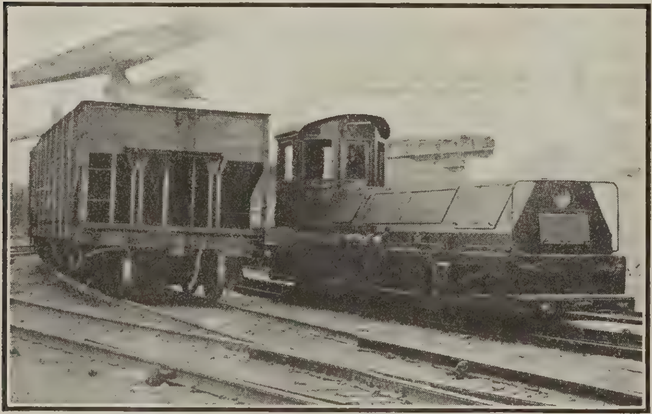
Ore Dock Electric Locomotive

For handling cars at their Cleveland ore docks, the Pennsylvania Lines West have recently had built three locomotives of unusual design.



Ore Dock Switching Locomotive.

The most novel feature in these locomotives is that they do not run on the same tracks as the cars they handle but on narrow gauge (42-inch) parallel tracks.



Locomotive Pushing Car.

They are not attached to the cars by couplings but each locomotive is equipped with an arm on each side which can be lowered by means of compressed air controlled from the cab and acts as a pusher, as shown in the illustration. Single cars or trains can be easily handled and cars can be shifted and cut out from trains with the least time and trouble.

The locomotives are of Baldwin-Westinghouse make and are 25 tons in weight. They have barsteel frames, which give great strength but permit ready access to the interior. The motors are of the Westinghouse Electric commutating-pole type. Power is obtained from two rails lying inside the rails on which the locomotives operate; these rails are protected by a wood covering.

Telephone Train Dispatching Equipment

The increasing use of the telephone system of train dispatching by leading railroads of this country and Canada is indeed worthy of comment. Quickness, the personal relationship factor, and absolute dependability have, for the most part, been responsible for the adoption of the telephone for use in dispatching trains. The past five years have witnessed a gradual but steady change—the abandonment of the time-honored telegraph and the adoption of telephone equipment.

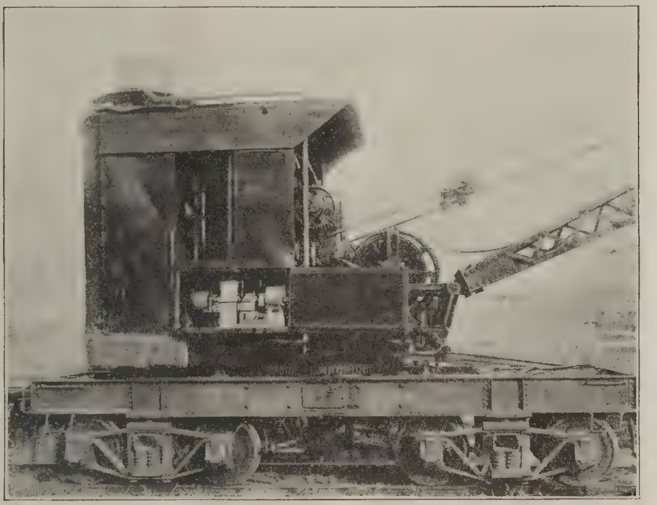
The telephone greatly simplifies the complex business of the train dispatcher. As a servant the telephone is always ready; as a saver of time and energy it has no equal. Experts agree that it makes for safer, more reliable and more efficient railroading.

Through the agency of the telephone discipline is enforced and efficiency increased. When a towerman comes under direct personal supervision of his chief by telephone he is more apt to carry out his orders with care and dispatch than if they are ticked in by the more or less impersonal telegraph sounder. Incidentally, the dispatcher can increase his range of operation by as much as 50 per cent.

In fact, the entire work of train dispatching has been reduced to a simple but definite conversation over the telephone. For example, there is the 80-mile circuit on the Western Maryland Railroad between Hagerstown and Cumberland. While this road does not handle many first class passenger trains a day, the dispatcher has his hands full maneuvering loose engines and freight trains. One thousand minutes out of the 1,440 in a day his wire is busy with orders governing the movement of approximately 200 trains, which come in and go out over one track. An average train order is given in two or three minutes, then he must answer about 1,600 reports of trains passing way-stations, and by the time he has attended to the miscellaneous calls that are bound to come up each day, he has done about all that it is possible for one man to do. With fifteen way station equipments and thirty siding telephones in use, the entire line is in constant touch with the dispatcher at the terminal.

Turbo Generators to Energize Crane Electro Magnets

The use of electro magnets with railroad crane cars receiving current from a separate source of power necessitates the use of service wires. These wires are in constant danger of being fouled with the attendant risk of causing the crane to drop whatever it is lifting at the time. To obviate this difficulty the Brown Hoisting Machinery Co. have installed on one of their 15 ton, 40 ft. boom cranes a turbo-generator set, made by the Terry Steam Turbine Co.



Turbo-Generator Mounted on Crane Outfit.

The electro magnet energized by this set is used for lifting pig iron and scrap. One of the special features of this unit is the turbine rotor, which is claimed to be immune to danger from the large quantities of water which are required to pass through turbine on starting. The direct connected generator is compound wound for 220 volts and is capable of a 50 per cent momentary overload. The whole unit is small and compact and is placed in a compartment beneath the floor, where it is entirely out of the way, and interfers in no way with the regular crane equipment which consists of the usual reciprocating engine outfit.

Overload Relays

Continuity of service is an essential consideration in all installations, and interruptions of the service cannot be tolerated unless the protection of the apparatus demands it. When they do occur they must be confined to the smallest area possible. The time element features of the Westinghouse overload relay facilitate this.

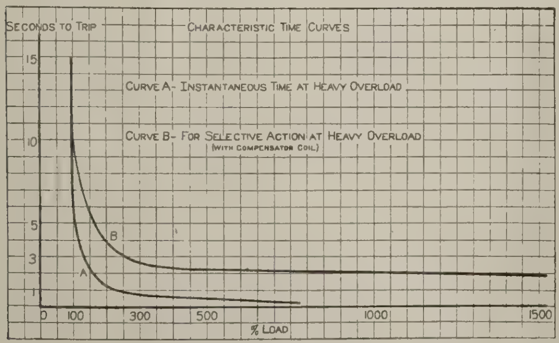


Fig. 1. Characteristic Time Curves.

Two forms of overload relay are supplied. Both have an inverse time element as shown in Figure 1. In one of the forms (Curve A), which has been on the market for some time, the relay trips instantaneously at extreme overloads. In the new form (Curve B) there is an adjustable definite minimum time element. This definite minimum can be adjusted for any point from 0 to 2 seconds in the standard relays, and special relays can be supplied giving up to 10 seconds minimum.

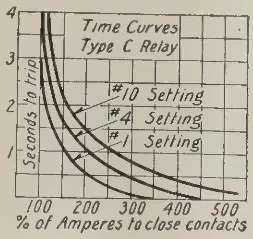


Fig. 3. Time Curves with Different Setting of Relay.

The definite minimum time element relay provides a selective action where substaions are placed in series at intervals along a transmission line, clearing the circuit at the last substation between the trouble and the generating station.

Another use of the definite minimum time element relay is in relieving circuit-breakers. It is well known that the ultimate breaking capacity of a circuit-breaker depends on the time of breaking. If a ground or short circuit can persist for two seconds before the circuit is opened, the ultimate breaking capacity is doubled; that is, the strain on the breaker is reduced to half, owing to the drop in voltage and current occurring during the interval.

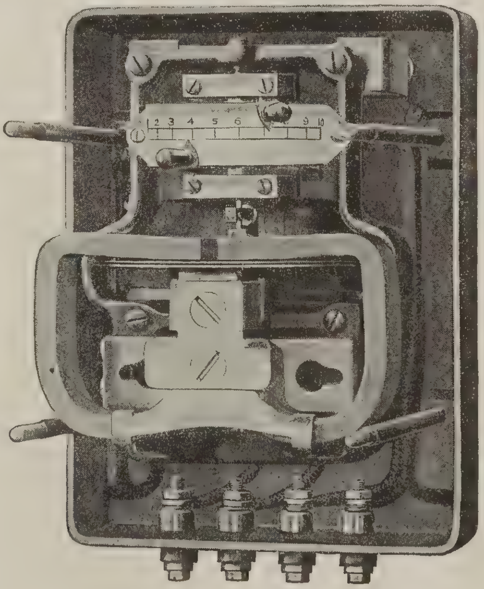


Fig. 4. Overload Relay.

This overload relay is manufactured by the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.

Telephone Train Dispatching

In the early days of railroading the only train dispatching necessary was to make sure that the track ahead was clear. When it became necessary to run two trains on a single track at the same time some means had to be devised to keep the trains from meeting each other. The telegraph solved this problem and from 1850 until 1907 this was the principal means of train dispatching. With the perfection of the telephone, its use for train dispatching was tried but the means of quickly calling any one of a number of stations in a dispatching territory was a difficult problem.

Many types of selectors have been developed which operated with more or less success. The Western Electric type is so arranged that a predetermined number of electrical impulses may be sent out at will from the dispatcher's office to signal any one of the way-stations. This apparatus consists of a key cabinet in which there are a number of keys, one for each of the way stations. These keys are so designed that the number of impulses sent by any one of them will actuate the corresponding selector at the way-station that is wanted.

Between terminal points and division headquarters it is possible to secure additional through telephone and telegraph circuits by simplexing and phantoming the train dispatching circuits. A simplex circuit is a telegraph circuit obtained by connecting repeating coils or retardation coils to the telephone circuit. These coils make it possible to carry on simultaneous telephone and telegraph communication over a single pair of wires without interference. A phantom circuit is a circuit obtained by connecting repeating or retardation coils to two existing metallic telephone circuits in such a manner that a third through telephone circuit is provided over the two pairs of wires. In this way three telephone conversations may be carried on over the two original circuits.

Of the 285,000 miles of railroad in the U. S. and Canada, 85,000 miles are now equipped for handling their train movements by means of the telephone. Selectively operated semaphores have also been installed by a number of railroads. The semaphore arms are operated through a local circuit which is energized by a selector connected to the train wire. An answer-back automatically notifies the dispatcher that the semaphore has been operated. The selector and telephone apparatus mounted in a waterproof compartment in the body of the semaphore mast enables the dispatcher to set the semaphore against a train and have the conductor telephone for orders.

The Western Electric Co. have recently issued an elaborate bulletin on this subject which may be had upon postal request to the company.

Railroad Coach Fans

Summer is the time of the greatest amount of travel on the part of the pleasure-seeking public. Unfortunately, with the hot sun beating upon the road beds and the dust flying in the open windows, it is the most difficult season of the year for railroad companies to furnish comfort to their travelers.

The car builders and railroad companies who stop to consider why they provide an adequate heating system for their cars in the winter know there is a reason for providing electric fans in summer. The prevailing custom of car builders now is to use electric light in their cars. It is, therefore, a simple matter to equip their cars with electric fans.

The Westinghouse standard coach fans embody certain modifications adapting them to railroad coach use. Their drawn steel frames—a— special Westinghouse feature—are characterized by grace and strength. They are quiet in operation, economical in use of current, and require no attention except oiling once every six months.

For use on private cars, sleepers, parlor cars, diners, and day coaches, where the railroad company realizes that to make the journey comfortable is the best way of pleasing its passengers, the wall-mounting fans are used. The wall-mounting fans have drawn steel frames, enclosed end brackets, and cast iron bases. They are furnished in two sizes: the 9-inch size being used especially in smoking compartments and lavatories, and the 12-inch size in the main part of the car, and are wound for 24 to 30 or for 60 volts direct current, as desired. A tooth joint with a thumb screw adjustment positively prevents the fan from tilting while the car is in motion. The fan can be readily removed from the bracket if desired. Either single-speed or three-speed fans may be used.

The three-speed fan has a controlling resistor enclosed in a brazed steel casing surrounding the motor frame but separated from it enough to allow ample ventilation for the motor. Being hermetically sealed, the resistor is not subject to deterioration due to exposure to the air, and will need no repairs. It is small and so placed around the motor frame that it adds to the beauty of the fan.

The standard blades are polished and lacquered brass, and the standard guard is dipped in lacquered brass. Two styles are supplied, one without a switch and the other with a switch mounted directly on the base. Either type is supplied single or three-speed.

For removing smoke, dust and the odors of cooked food from the kitchens of dining cars and from buffet cars, the standard single-speed 12-inch exhaust fans are used. They are wound for 24 to 30 or for 60 volts direct current. A speed regulator to give two additional speeds can be furnished when desired.

I. E. S. Convention

All preparations have been completed for the reception of delegates and guests at the 8th Annual Convention of the Illuminating Engineering Society to be held in Cleveland September 21st to 26th.

The program will be highly interesting as shown by the program given below:

Monday—September 21:

Morning session—business meeting.
Afternoon Session, 2:00 to 5:00.
Color of Illuminants—L. A. Jones.
Artificial Daylight: Its Production and Use—M. Luciesh and F. E. Cady.
Development of Daylight Glass—E. J. Brady.

Tuesday—September 22:

Morning session, 9:30 to 12:30.
Relation of Light to the Critical Inspection of Documents —A. S. Osborn.
Planning for Daylight and Sunlight in Buildings—L. B. Marks and B. E. Woodwell.
Air-Shaft Illumination as Studied by Models—C. H. Sharp.
Evening Lecture Session, 8:15 to 10:15.
Photo Sculpturing and the Use of Light in the Reproduction and Illumination of Sculpture—John Hammond Smith.
Color Photography—M. C. Rypinski.

Wednesday—September 23:
Morning Commercial Session, 9:30 to 12:30.
The Locomotive Headlight—J. L. Minick.
Present Practice in the Use of Tungsten Filament Lamps for the Lighting of Metal Working Plants—A. L. Powell and R. E. Harrington.
Factory Lighting: Cost Maintenance and Installation Data —O. R. Hogue and A. O. Dickerr.
Morning Laboratory Session, 9:30 to 12:30.
Light Filters for use in Photometry—C. E. K. Mees.
Experiments with Colored Absorbing Solutions for Use Heterochromatic Photometry—H. E. Ives and E. F. Kingsbury.
Characteristic Equations of Tungsten Filament Lamps and Their Application in Heterochromatic Photometry—G. W. Middlekauff and J. F. Skigland.
A Transmission and Absorption Photometer for Small Areas (to be read in title)—P. G. Nutting and L. A. Jones.
Afternoon Commercial Session, 2:00 to 5:00.
Recent Improvements in Incandescent Gas Lighting—R. F. Pierce.
Characteristics of Gas-Filled Lamps—G. M. C. MacKay.
The Lighting of Rooms Through Translucent Glass Ceilings.
Afternoon Laboratory Session, 2:00 to 5:00.
Mixed Specular and Diffuse Reflection—P. G. Nutting.
Notes on Integrating Sphere and Arc Lamp Photometry—N. K. Chaney and E. L. Clark.
A New Standard Light Source—(to be read in title)—L. A. Jones.
Some Tests of Possible Reflecting Power Standards (to be read in title)—P. G. Nutting, L. A. Jones and F. A. Elliott.

Thursday—September 24:
Morning Session, 9:30 to 12:30.
Some Uses of Light in the Treatment of Disease. E. C. Titus.
Some Experiments with the Ferree Test for Eye Fatigue—J. R. Cravath.
Further Experiments on the Efficiency of the Eye under Different Conditions of the Lighting—C. E. Ferree and G. Rand.
Evening Session, 7:30 to 8:30.
The Visibility of Radiation—P. G. Nutting.
Some Recent Experiments on Vision in Animals—H. M. Johnson.

The rest of the convention will be given over to social activities.

School of Electricity

A Course of Training Prepared by the Pennsylvania Railroad for Its Employees

Lesson No. 15

Fractions

A fraction is one or more of the equal parts of a unit; for example, $\frac{7}{8}, \frac{4}{5}, \frac{3}{4}$. Thus: take the fraction $\frac{3}{4}$ inch, which means that 1 inch is divided into 4 equal parts, each part being $\frac{1}{4}$ of an inch in length, and that 3 of these parts are taken. When it is said that an iron bar is $\frac{3}{4}$ inch thick, it means that the inch is divided into 4 equal parts, and that the bar is as thick as 3 of these parts. The 3 is the numerator and the 4 the denominator.

The **terms** of a fraction are the numerator and denominator

The **denominator** of a fraction shows the number of equal parts into which the unit is divided. It is written below the line.

The **numerator** of a fraction shows how many of these parts are taken. It is written above the line.

The **line** between the numerator and denominator indicates division, and means **divided by.** Thus: $\frac{2}{3}$ means that 2 is divided by 3 and is equivalent to 2 ÷ 3.

A **proper fraction** is a fraction whose numerator is less than its denominator; for example, $\frac{1}{2}, \frac{4}{5}, \frac{6}{7}, \frac{7}{8}$.

An **improper fraction** is a fraction whose numerator is equal to or greater than its denominator; for example, $\frac{4}{4}, \frac{5}{4}, \frac{7}{6}$.

A **mixed number** is a number expressed by a whole number, or integer, and a fraction. Thus: $6\frac{2}{3}$ is a mixed number, and is read six and two-thirds.

A **complex fraction** is a fraction in which either the numerator, or the denominator, or both are fractions. Thus: $\frac{2}{\frac{1}{2}}$ which is read two divided by one-half; and $\frac{\frac{2}{3}}{\frac{4}{5}}$ which is read two-thirds divided by four-fifths, are complex fractions.

Whenever a heavy line is used, as shown in these complex fractions, it means that all above this line is to be divided by all below it.

READING AND WRITING FRACTIONS.

A fraction is read by reading the numerator (the number of parts) and then the denominator (the size of parts). Thus: $\frac{4}{5}$ is read four-fifths.

$\frac{1}{2}$ is read one-half
$\frac{2}{3}$ is read two-thirds
$\frac{5}{6}$ is read five-sixths.
$\frac{11}{12}$ is read eleven-twelfths.
$\frac{27}{45}$ is read twenty-seven forty-fifths.

A fraction is written by placing the numerator (the number of parts) above the line, and the denominator (the size of parts) below the line. Thus: three-fifths is written $\frac{3}{5}$.

Four-sevenths is written $\frac{4}{7}$.
Six-eighths is written $\frac{6}{8}$.
Seven-elevenths is written $\frac{7}{11}$
Eleven-fifteenths is written $\frac{11}{15}$.
Thirteen-twentieths is written $\frac{13}{20}$.

REDUCTION OF FRACTIONS.

Reduction of fractions is the process of changing their form without changing their value.

To reduce a fraction to higher terms.

Rule 1:—*Multiply both the numerator and the denominator of the given fraction by a number which is found by dividing the desired denominator by the denominator of the given fraction.*

Example:

Reduce $\frac{3}{4}$ to an equivalent fraction having 8 for its denominator.

Solution:

8, the desired denominator, divided by 4, the given denominator = 2. Multiply both numerator and denominator by 2, as follows: $\frac{3\times 2}{4\times 2}=\frac{6}{8}$. The value is not changed because $\frac{3}{4}=\frac{6}{8}$, as shown in Fig. 1.

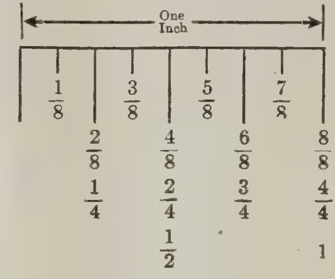


Fig. 1.

To reduce a fraction to lower terms.

Rule 2:—*Divide both numerator and denominator by the same number.*

Example:

Reduce $\frac{4}{8}$ to lower terms.

Solution:

$\frac{4}{8}$ is reduced to lower terms by dividing both numerator and denominator by 2, as follows: $\frac{4\div 2}{8\div 2}=\frac{2}{4}$. The value is not changed because $\frac{4}{8}=\frac{2}{4}$ as shown in Fig 1.

A fraction is **reduced to its lowest terms** when both its numerator and denominator cannot be divided by the same number without a remainder. Thus: each of the fractions $\frac{1}{4}, \frac{4}{5}, \frac{6}{7}, \frac{7}{8}$ is reduced to its lowest terms, for no number except 1 will exactly divide both numerator and denominator of any one of them.

Example·

Reduce $\frac{4}{32}$ to its lowest terms.

Solution

Since dividing both terms of a fraction by the same number does not change its value, divide each term by 4, as this is the largest number that is contained in both the numerator and the denominator without a remainder. $\frac{4\div 4}{32\div 4}=\frac{1}{8}$, which fraction is in its lowest terms, since neither of the terms in the fraction, $\frac{1}{8}$, can be divided by the same number, except 1, without a remainder.

A **common divisor** of two or more numbers is a number that exactly divides each of them. Thus: 5 is a *common divisor* of 15 and 20.

Similar fractions are fractions that have the same denominator Thus· $\frac{2}{5}$ and $\frac{3}{5}$ are similar fractions, as both have the same denominator, 5.

Dissimilar fractions are fractions that do not have the same denominator Thus: $\frac{2}{3}$ and $\frac{4}{5}$ are dissimilar fractions, as one has the denominator 3, and the other, 5.

A **common denominator** of two or more fractions is a number which is exactly divisible by the denominators of each fraction. Thus 50 is a common denominator of $\frac{3}{10}$ and $\frac{4}{5}$, because 50 is divisible by each of the denominators, 10 and 5, without a remainder.

The **least common denominator** (abbreviation L. C. D.) of two or more fractions is the smallest number that is exactly divisible by the denominators of each fraction. Thus: 10 is the least common denominator of $\frac{3}{10}$ and $\frac{4}{5}$, because 10 is the smallest number that is divisible by each of the denominators, 10 and 5, without a remainder.

To reduce fractions to equivalent fractions having a common denominator.

Rule 3:—*Multiply both terms of each fraction by the denominators of each of the other fractions.*

Example:

Reduce $\frac{3}{4}, \frac{1}{2}, \frac{3}{5}$ to fractions having a common denominator.

Solution:

A common denominator of these fractions is a number that will exactly contain 4, 2, and 5, and is $4\times 2\times 5=40$. Multiply both terms of $\frac{3}{4}$ by 2 and 5 (the denominators of the other fractions), as follows: $\frac{3\times 2\times 5}{4\times 2\times 5}=\frac{30}{40}$; likewise multiply both terms of $\frac{1}{2}$ by 4 and 5 (the denominators of the other fractions), $\frac{1\times 4\times 5}{2\times 4\times 5}=\frac{20}{40}$; and both terms of $\frac{3}{5}$ by 4 and 2 (the denominators of the other fractions), $\frac{3\times 4\times 2}{5\times 4\times 2}=\frac{24}{40}$.

Therefore, $\frac{3}{4}=\frac{30}{40}, \frac{1}{2}=\frac{20}{40}$ and $\frac{3}{5}=\frac{24}{40}$.

Example:

Find the least common denominator of $\frac{3}{4}, \frac{5}{8}, \frac{4}{9}$, and $\frac{1}{24}$.

Solution:

$$\begin{array}{r|rrrr} 2 & 4 & 8 & 9 & 24 \\ \hline 2 & 2 & 4 & 9 & 12 \\ \hline 2 & 1 & 2 & 9 & 6 \\ \hline 3 & 1 & 1 & 9 & 3 \\ \hline & 1 & 1 & 3 & 1 \end{array}$$

The least common denominator is $2\times 2\times 2\times 3\times 3=72$.

Explanation: Place the denominators of the fractions in a row, separating each by a space. Draw a line to the left of the first number, and below all of the numbers. Divide them by any prime number that is contained into at least two of them without a remainder, and bring down those numbers to the row below which will not contain the divisor without a remainder. One of the prime numbers which is contained into at least two of them without a remainder is 2. Divide by 2, and the result is 2, 4, 9, 12. Divide the second row of numbers by 2, and the result is 1, 2, 9, 6. Divide the third row by 2, and the result is 1, 1, 9, 3. Divide the fourth row by 3, and the result is 1, 1, 3, 1. Therefore, the least common denominator, L. C. D., in this example is $2\times 2\times 2\times 3\times 3=72$.

Note:—In any problem this process is continued until no prime number, except 1, will exactly divide more than one of the remaining numbers. The Least Common Denominator is, then, the product of all the divisors and the numbers remaining in the last line.

To reduce whole or mixed numbers to improper fractions.

Rule 4:—*Multiply the whole number by the denominator of the fraction, add the numerator to the product, and write the denominator under the sum.*

Example:

Reduce 8 to an improper fraction having 4 as a denominator.

Solution:

In 1 there are 4 fourths, and in 8 there are 8×4 fourths $=32$ fourths, or $\frac{32}{4}$.

This may be written $8\times\frac{4}{4}=\frac{32}{4}$.

Example:

Reduce $5\frac{2}{3}$ to an improper fraction.

Solution:

In 1 there are 3 thirds, and in 5 there are 5×3 thirds = 15 thirds, $\frac{15}{3}$, which, added to the $\frac{2}{3}$, make 17 thirds, or $\frac{17}{3}$.

Or: $5\times\frac{3}{3}=\frac{15}{3}$, and $\frac{15}{3}+\frac{2}{3}=\frac{17}{3}$.

This may be written $\frac{(3\times 5)+2}{3}=\frac{15+2}{3}=\frac{17}{3}$.

To reduce an improper fraction to a whole or mixed number.

Rule 5:—*Divide the numerator by the denominator; the quotient will be the whole number, and the remainder, if there be any, will be the numerator of the fraction having the same denominator as the improper fraction.*

Example:

Reduce $\frac{64}{16}$ to a whole or mixed number.

Solution.

16 is contained in 64, 4 times without a remainder.

Therefore, $\frac{64}{16} = 4$.

Example:

Reduce $\frac{17}{2}$ to a mixed number.

Solution.

2 is contained in 17, 8 times with a remainder of 1 As this 1 is also divided by 2, its value is $\frac{1}{2}$. Therefore, $\frac{17}{2} = 8 + \frac{1}{2} = 8\frac{1}{2}$.

Example.

Reduce $\frac{35}{14}$ to a mixed number

Solution:

$$\begin{array}{r|l|l} 14) & 35\ (2 & \\ & 28 & \\ 7 & \frac{7}{14} & \frac{1}{2} \end{array}$$

This is a common method of solving problems of this nature. The divisor is placed beneath the remainder as shown, and the fraction is then reduced to its lowest terms.

Therefore $\frac{35}{14} = 2\frac{1}{2}$.

Note:—It is always customary to reduce the fractional part of the mixed number to its lowest terms, as shown.

ADDITION OF FRACTIONS.

Addition of fractions is the process of finding the sum of two or more fractions.

To add fractions.

Rule 6:—*Reduce the fractions to equivalent fractions having a common denominator; then add their numerators, and place this sum over the common denominator.*

A common fraction denotes that a thing has been divided into a number of equal parts; thus, if 1 inch is divided into 8 equal parts, and 3 of these parts are taken, this will make $\frac{3}{8}$ of an inch; or if it is divided into 16 equal parts, and 7 of these parts are taken, this will make $\frac{7}{16}$ of an inch. Now, in order to add fractions, their denominators, which represent the number of equal parts into which the thing is divided, must be of the same size. $\frac{1}{4}$ of a foot cannot be added to $\frac{1}{2}$ of a foot before first finding out how many fourths there are in $\frac{1}{2}$, because the denominator denotes the number of equal parts into which the unit is divided, which, in the first case, is 4 equal parts, and in the second case, 2 equal parts. These parts are of unequal size and cannot be added until reduced to a common denominator. In $\frac{1}{2}$ there are $\frac{2}{4}$ Therefore, $\frac{1}{4}$ of a foot + $\frac{2}{4}$ of a foot equals $\frac{3}{4}$ of a foot.

Similarly, in order to add $\frac{1}{2}$ of an inch to $\frac{3}{4}$ of an inch, it is necessary to find out how many fourths there are in $\frac{1}{2}$. In $\frac{1}{2}$ there are $\frac{2}{4}$.

Therefore, $\frac{2}{4}$ in. + $\frac{3}{4}$ in. = $\frac{5}{4}$ in. or $1\frac{1}{4}$ inches.

Example:

$$\frac{4}{5} + \frac{8}{9}.$$

Solution:

The common denominator is the product of their denominators, or $9 \times 5 = 45$. Hence, $\frac{4 \times 9}{5 \times 9} = \frac{36}{45}$ and $\frac{8 \times 5}{9 \times 5} = \frac{40}{45}$.

Therefore, $\frac{36}{45} + \frac{40}{45} = \frac{76}{45} = 1\frac{31}{45}$.

To add mixed numbers.

Rule 7:—*Add the whole numbers and fractions separately; then add the results together.*

Example:

$$15\frac{1}{4} + 20\frac{1}{2}.$$

Solution:

$$15 + 20 = 35, \text{ and } \frac{1}{4} + \frac{1}{2} = \frac{3}{4}.$$

Therefore, $15\frac{1}{4} + 20\frac{1}{2} = 35 + \frac{3}{4} = 35\frac{3}{4}$.

This operation may be written

$$\begin{aligned} 15\frac{1}{4} &= 15\frac{1}{4} \\ 20\frac{1}{2} &= 20\frac{2}{4} \\ \hline & \quad 35\frac{3}{4} \end{aligned}$$

In case the sum of the fractions is equal to or greater than 1, add to the sum of the whole numbers, the number of units made by the fractions.

Example:

$$20\frac{7}{8} + 23\frac{3}{4}.$$

Solution:

$$20 + 23 = 43, \text{ and } \frac{7}{8} + \frac{3}{4} = \frac{7}{8} + \frac{6}{8} = \frac{13}{8} = 1\frac{5}{8}.$$

Therefore, $20\frac{7}{8} + 23\frac{3}{4} = 43 + 1\frac{5}{8} = 44\frac{5}{8}$.

This operation may be written

$$\begin{aligned} 20\frac{7}{8} &= 20\frac{7}{8} \\ 23\frac{3}{4} &= 23\frac{6}{8} \\ \hline 43\frac{13}{8} &= 44\frac{5}{8} \end{aligned}$$

Example:

What is the total length of two pieces of pipe $27\frac{5}{8}$ inches and $23\frac{1}{2}$ inches long respectively?

Solution:

$$27 + 23 = 50, \text{ and } \frac{5}{8} + \frac{1}{2} = \frac{9}{8} = 1\frac{1}{8}$$

Therefore, $27\frac{5}{8} + 23\frac{1}{2} = 50 + 1\frac{1}{8} = 51\frac{1}{8}$, the total length in inches.

This operation may be written

$$\begin{aligned} 27\frac{5}{8} &= 27\frac{5}{8} \\ 23\frac{1}{2} &= 23\frac{4}{8} \\ \hline 50\frac{9}{8} &= 51\frac{1}{8} \end{aligned}$$

Example:

How long must a piece of iron be to cut from it four pieces, $4\frac{1}{2}''$, $2\frac{3}{4}''$, $11\frac{2}{3}''$, and $15\frac{5}{6}''$ long respectively? (The sign ″ denotes inches.)

Solution:

Add the whole numbers, $4 + 2 + 11 + 15 = 32$. To add the fractions, first find their least common denominator; thus,

$$\begin{array}{l} 2)\underline{2\ 4\ 3\ 6} \\ 3)\underline{1\ 2\ 3\ 3} \\ \quad 1\ 2\ 1\ 1 \end{array}$$

Their least common denominator is then $2 \times 3 \times 2 = 12$.

Then, $\frac{1}{2} = \frac{6}{12}$, $\frac{3}{4} = \frac{9}{12}$, $\frac{2}{3} = \frac{8}{12}$, and $\frac{5}{6} = \frac{10}{12}$.

$$\frac{6}{12} + \frac{9}{12} + \frac{8}{12} + \frac{10}{12} = \frac{33}{12} = 2\frac{9}{12} \text{ or } 2\frac{3}{4}.$$

Therefore, $4\frac{1}{2}'' + 2\frac{3}{4}'' + 11\frac{2}{3}'' + 15\frac{5}{6}'' = 32'' + 2\frac{3}{4}'' = 34\frac{3}{4}''$, the length of the piece necessary.

SUBTRACTION OF FRACTIONS.

Subtraction of fractions is the process of finding the difference between two fractions

To subtract fractions.

Rule 8:—*Reduce the fractions to a common denominator; then take the difference between the numerators, and place the result over the common denominator*

Example

Subtract $\frac{3}{4}$ from $\frac{4}{5}$ This problem may also be written $\frac{4}{5}-\frac{3}{4}$.

Solution

Reduce the fractions to fractions having the same denominator, $\frac{4\times4}{5\times4}=\frac{16}{20}$, and $\frac{3\times5}{4\times5}=\frac{15}{20}$.

Therefore, $\frac{4}{5}-\frac{3}{4}=\frac{16}{20}-\frac{15}{20}=\frac{1}{20}$.

To subtract mixed numbers.

Rule 9:—*Subtract the whole numbers and fractions separately; then take the sum of the remainders.*

Example

What is the difference between $15\frac{6}{7}$ and $13\frac{2}{3}$?

This problem may also be written $15\frac{6}{7}-13\frac{2}{3}$.

Solution:

$15-13=2$, and $\frac{6}{7}-\frac{2}{3}=\frac{18}{21}-\frac{14}{21}=\frac{4}{21}$.

Therefore, $15\frac{6}{7}-13\frac{2}{3}=2+\frac{4}{21}=2\frac{4}{21}$.

This operation may be written
$$\begin{array}{r} 15\frac{6}{7}=15\frac{18}{21}\\ 13\frac{2}{3}=13\frac{14}{21}\\ \hline 2\frac{4}{21}\end{array}$$

Example

What is the difference in the length of two pieces of conduit $23\frac{1}{4}''$ and $17\frac{7}{8}''$ long respectively?

Solution:

$\frac{1}{4}=\frac{2}{8}$. In this case, $\frac{7}{8}$ cannot be subtracted from $\frac{2}{8}$; so 1 is taken from 23, leaving 22, and added to the fraction $\frac{2}{8}$, making it $1\frac{2}{8}$ or $\frac{10}{8}$. $23\frac{1}{4}$ may then be written $22\frac{10}{8}$.

Subtract the fractions; thus, $\frac{10}{8}-\frac{7}{8}=\frac{3}{8}$. Then subtract the whole numbers; thus, $22-17=5$.

Therefore, $23\frac{1}{4}-17\frac{7}{8}=5+\frac{3}{8}=5\frac{3}{8}$.

This operation may be written
$$\begin{array}{r} 23\frac{1}{4}=22\frac{10}{8}\\ 17\frac{7}{8}=17\frac{7}{8}\\ \hline 5\frac{3}{8}\end{array}$$

Example:

From a piece of wire $28\frac{3}{4}''$ long, a piece $17\frac{3}{8}''$ is cut. How long is the remaining piece?

Solution:

$\frac{3}{4}''=\frac{6}{8}''$. Then $\frac{6}{8}''-\frac{3}{8}''=\frac{3}{8}''$, and $28''-17''=11''$

Therefore, $28\frac{3}{4}''-17\frac{3}{8}''=11''+\frac{3}{8}''=11\frac{3}{8}''$

This operation may be written
$$\begin{array}{r} 28\frac{3}{4}=28\frac{6}{8}\\ 17\frac{3}{8}=17\frac{3}{8}\\ \hline 11\frac{3}{8}\end{array}$$

Note:—Mixed numbers may also be subtracted by reducing them to improper fractions and proceeding as in Rule 8.

Example:

$40\frac{1}{3}-14\frac{1}{7}$.

Solution:

$40\frac{1}{3}=\frac{121}{3}$, and $14\frac{1}{7}=\frac{99}{7}$. The common denominator is 21; then $\frac{121}{3}=\frac{121\times7}{3\times7}=\frac{847}{21}$, and $\frac{99}{7}=\frac{99\times3}{7\times3}=\frac{297}{21}$

Therefore, $40\frac{1}{3}-14\frac{1}{7}=\frac{847}{21}-\frac{297}{21}=\frac{550}{21}=26\frac{4}{21}$.

MULTIPLICATION OF FRACTIONS.

Multiplication of fractions is the process of finding the product of two or more fractions.

To multiply a fraction by a fraction.

Rule 10:—*Multiply the numerators together to obtain the numerator of the product, and multiply the denominators together to obtain the denominator of the product.*

Example

Find the product of $\frac{7}{8}\times\frac{5}{16}$.

Solution:

The product of the numerators is $7\times5=35$, and the product of the denominators is $8\times16=128$.

Therefore, $\frac{7}{8}\times\frac{5}{16}=\frac{35}{128}$.

Note:—The word *of* between fractions or between a fraction and a whole number means the same as the multiplication sign.

Example:

$\frac{4}{5}$ of $\frac{2}{3}=\frac{4}{5}\times\frac{2}{3}=\frac{8}{15}$.

Example:

$\frac{2}{3}$ of $\frac{12}{5}=\frac{2}{3}\times\frac{12}{5}=\frac{24}{15}=1\frac{9}{15}=1\frac{3}{5}$.

To multiply a fraction by a whole number.

Rule 11:—*Multiply the numerator of the fraction by the whole number, and place the product thus obtained over the denominator.*

Example

Multiply $\frac{5}{6}$ by 7.

Solution:

Multiply the numerator of the fraction by the whole number; thus, $\frac{5}{6}\times7=\frac{35}{6}$ or $5\frac{5}{6}$.

Example:

What will be the total length of 9 pieces of tool steel each $\frac{7}{8}$ of a foot long?

Solution:

The total length of the pieces may be found by multiplying the numerator of the fraction by the whole number; thus, $9\times\frac{7}{8}$ ft. $=\frac{63}{8}$ ft. or $7\frac{7}{8}$ feet.

Example:

How many feet in $\frac{1}{2}$ mile?

Solution:

There are 5280 feet in 1 mile, and in $\frac{1}{2}$ mile there are $\frac{1}{2}$ of 5280 ft. $=\frac{5280}{2}$ ft $=2640$ feet

To multiply a mixed number by a whole number.

Rule 12:—*Multiply the whole numbers together, then multiply the fraction of the mixed number by the whole number, and add the products thus obtained.*

Example:

Multiply $23\frac{1}{4}$ by 3.

Solution:

$23\times3=69$, and $\frac{1}{4}\times3=\frac{3}{4}$.

Therefore, $23\frac{1}{4}\times3=69+\frac{3}{4}=69\frac{3}{4}$.

This operation may be written
$$\begin{array}{r} 23\frac{1}{4}\\ 3\\ \hline 69\frac{3}{4}\end{array}$$

Example:

$31\frac{3}{4}\times3$.

Solution:

$31\times3=93$, and $\frac{3}{4}\times3=\frac{9}{4}=2\frac{1}{4}$.

Therefore, $31\frac{3}{4}\times3=93+2\frac{1}{4}=95\frac{1}{4}$.

This operation may be written
$$\begin{array}{r} 31\frac{3}{4} \\ 3 \\ \hline 93 \\ 2\frac{1}{4} \\ \hline 95\frac{1}{4} \end{array}$$

Example:

If wire nails cost 9 cents per pound, what will $11\frac{1}{4}$ pounds cost?

Solution:

11×9 cents $=$ 99 cents, and $\frac{1}{4} \times 9$ cents $= \frac{9}{4}$ cents $= 2\frac{1}{4}$ cents.

Therefore, $11\frac{1}{4} \times 9$ cents $=$ 99 cents $+ 2\frac{1}{4}$ cents $= 101\frac{1}{4}$ cents, or $\$1.01\frac{1}{4}$.

This operation may be written
$$\begin{array}{r} 11\frac{1}{4} \\ 9 \\ \hline 99 \\ 2\frac{1}{4} \\ \hline 101\frac{1}{4} \end{array}$$

To multiply one mixed number by another mixed number.

Rule 13:—*Reduce both mixed numbers to improper fractions and proceed as when multiplying a fraction by a fraction.*

Example:

Multiply $3\frac{1}{2}$ by $5\frac{3}{5}$.

Solution:

$3\frac{1}{2} = \frac{7}{2}$, and $5\frac{3}{5} = \frac{28}{5}$.

Therefore, $3\frac{1}{2} \times 5\frac{3}{5} = \frac{7}{2} \times \frac{28}{5} = \frac{196}{10} = 19\frac{6}{10}$ or $19\frac{3}{5}$.

DIVISION OF FRACTIONS.

Division of fractions is the process of finding the quotient of two fractions.

To divide a fraction by a fraction.

Rule 14:—*Invert the divisor; then multiply the numerators together for the numerator of the quotient, and the denominators together for the denominator of the quotient.*

To *invert* a fraction is to turn it upside down; thus, $\frac{3}{4}$ inverted is $\frac{4}{3}$, $\frac{5}{6}$ inverted is $\frac{6}{5}$, 5 inverted is $\frac{1}{5}$, and $\frac{1}{5}$ inverted is 5.

When a whole number is inverted it becomes the denominator of a fraction with 1 for its numerator; thus, 4 inverted becomes $\frac{1}{4}$, 12 inverted becomes $\frac{1}{12}$, etc.

A whole number, when standing alone, is always considered as having 1 for its denominator; thus, $4 = \frac{4}{1}$, $12 = \frac{12}{1}$, etc.

Example:

Divide $\overset{\text{Dividend}}{\frac{4}{5}}$ by $\overset{\text{Divisor}}{\frac{8}{9}}$

Solution:

The divisor, $\frac{8}{9}$, when inverted is $\frac{9}{8}$

Multiply the numerators together and the denominators together; thus, $\frac{4 \times 9}{5 \times 8} = \frac{36}{40}$. This fraction, $\frac{36}{40}$, reduced to lowest terms by dividing both numerator and denominator by the same number, 4, equals $\frac{36 \div 4}{40 \div 4} = \frac{9}{10}$.

Example:

$\frac{4}{5} \div \frac{3}{4}$.

Solution:

Invert the divisor and multiply; thus, $\frac{4}{5} \div \frac{3}{4} = \frac{4}{5} \times \frac{4}{3} = \frac{16}{15} = 1\frac{1}{15}$.

To divide a fraction by a whole number.

Rule 15:—*Invert the whole number and proceed as in the multiplication of fractions.* (See Rule 10.)

Example:

$\frac{8}{15} \div 2$.

Solution:

2 inverted $= \frac{1}{2}$.

$\frac{8}{15} \div 2 = \frac{8}{15} \times \frac{1}{2} = \frac{8}{30} = \frac{4}{15}$.

Example:

A bar of copper $\frac{8}{12}$ of a foot long is to be cut into 3 equal parts. What will be the length of each part?

Solution:

$\frac{8}{12}$ ft. $\div 3 = \frac{8}{12}$ ft. $\times \frac{1}{3} = \frac{8}{36}$ ft. $= \frac{2}{9}$ ft., the length of each part.

To divide a whole number by a fraction.

Rule 16:—*Invert the fraction and proceed as in the multiplication of a fraction by a whole number.* (See Rule 11.)

Example:

$46 \div \frac{4}{7}$.

Solution:

$\frac{4}{7}$ inverted $= \frac{7}{4}$.

$46 \div \frac{4}{7} = 46 \times \frac{7}{4} = \frac{322}{4} = 80\frac{2}{4} = 80\frac{1}{2}$.

Example:

A 10-pound box of rivets was divided into $\frac{1}{2}$ pound lots. How many portions were there?

Solution:

$10 \div \frac{1}{2} = 10 \times \frac{2}{1} = \frac{20}{1} = 20$, the number of portions.

To divide a mixed number by a whole number.

Rule 17:—*Reduce the mixed number to an improper fraction and proceed the same as to divide a fraction by a whole number.* (See Rule 15.)

Example:

$20\frac{3}{5} \div 4$.

Solution:

$20\frac{3}{5} = \frac{103}{5}$.

$\frac{103}{5} \div 4 = \frac{103}{5} \times \frac{1}{4} = \frac{103}{20} = 5\frac{3}{20}$.

Example:

A flywheel makes $15\frac{5}{6}$ revolutions in 5 seconds. How many revolutions does it make in one second?

Solution:

$15\frac{5}{6} = \frac{95}{6}$.

$\frac{95}{6} \div 5 = \frac{95}{6} \times \frac{1}{5} = \frac{95}{30} = 3\frac{5}{30} = 3\frac{1}{6}$, the number of revolutions per second.

To divide a whole number by a mixed mumber.

Rule 18:—*Reduce the mixed number to an improper fraction and proceed the same as to divide a whole number by a fraction.* (See Rule 16.)

Example:

$24 \div 3\frac{1}{8}$.

Solution:

$3\frac{1}{8} = \frac{25}{8}$.

$24 \div 3\frac{1}{8} = 24 \div \frac{25}{8} = 24 \times \frac{8}{25} = \frac{192}{25} = 7\frac{17}{25}$.

Example:

A barrel of oil weighs 390 pounds. If a gallon weighs $7\frac{1}{2}$ pounds, how many gallons are there in the barrel?

Solution:

$$7\frac{1}{2}=\frac{15}{2}.$$

$$390\div7\frac{1}{2}=390\div\frac{15}{2}=390\times\frac{2}{15}=\frac{780}{15}=52,$$ the number of gallons.

To divide a mixed number by a mixed number.

Rule 19:—*Reduce both mixed numbers to improper fractions and proceed the same as to divide a fraction by a fraction.* (See Rule 14.)

Example:

$$21\frac{3}{7}\div12\frac{8}{21}.$$

Solution:

$$21\frac{3}{7}=\frac{150}{7},\text{ and }12\frac{8}{21}=\frac{260}{21}.$$

$$21\frac{3}{7}\div12\frac{8}{21}=\frac{150}{7}\div\frac{260}{21}=\frac{150}{7}\times\frac{21}{260}=\frac{3150}{1820}=1\frac{1330}{1820}=1\frac{19}{26}.$$

A shorter way to solve such problems is by cancellation.

$$\frac{\overset{15}{\cancel{150}}}{\cancel{7}}\times\frac{\overset{3}{\cancel{21}}}{\underset{26}{\cancel{260}}}=\frac{45}{26}=1\frac{19}{26}.$$

Example:

A water tank holds $82\frac{1}{2}$ gallons. How many times can a pail holding $2\frac{3}{4}$ gallons be filled from it?

Solution

$$82\frac{1}{2}=\frac{165}{2},\text{ and }2\frac{3}{4}=\frac{11}{4}.$$

$$82\frac{1}{2}\div2\frac{3}{4}=\frac{165}{2}\div\frac{11}{4}=\frac{165}{2}\times\frac{4}{11}.$$

By cancellation:

$$\frac{\overset{15}{\cancel{165}}}{\cancel{2}}\times\frac{\overset{2}{4}}{\cancel{11}}=30,$$ the number of times.

PROBLEMS.

Note:—These problems should be answered one or more complete lessons at a time.

First Lesson.

1. Reduce (*a*) $\frac{3}{4}, \frac{2}{3}, \frac{5}{6}$ to twelfths. (*b*) $\frac{4}{5}, \frac{5}{6}, \frac{7}{10}$ to thirtieths.

2. Reduce the following fractions to lowest terms: (*a*) $\frac{14}{21}$; (*b*) $\frac{18}{30}$; (*c*) $\frac{72}{288}$; (*d*) $\frac{288}{864}$.

3. Reduce to improper fractions: (*a*) $4\frac{1}{5}$; (*b*) $12\frac{2}{3}$; (*c*) $17\frac{6}{13}$; (*d*) $49\frac{3}{64}$.

4. Reduce to whole or mixed numbers: (*a*) $\frac{25}{3}$; (*b*) $\frac{1728}{12}$; (*c*) $\frac{328}{49}$; (*d*) $\frac{1421}{125}$.

5. Reduce to the least common denominator: (*a*) $\frac{1}{4}, \frac{11}{12}, \frac{13}{20}$; (*b*) $\frac{6}{9}, \frac{12}{14}, \frac{15}{18}, \frac{21}{36}$.

Second Lesson.

6. Find the sum of: (*a*) $\frac{2}{3}, \frac{3}{5}, \frac{6}{7}$; (*b*) $\frac{12}{13}, \frac{3}{4}, \frac{7}{8}$.

7. Add the fractions: (*a*) $\frac{4}{5}, \frac{5}{6}, \frac{1}{15}$; (*b*) $\frac{11}{12}, \frac{1}{6}, \frac{3}{4}$; (*c*) $\frac{4}{13}+\frac{16}{17}+\frac{3}{125}$.

8. Find the result of: (*a*) $3\frac{1}{2}+4\frac{3}{4}+1\frac{1}{2}$; (*b*) $7\frac{2}{3}+6\frac{1}{5}+3\frac{4}{5}$; (*c*) $13\frac{5}{8}+29\frac{3}{15}+8\frac{7}{60}$.

9. Solve: (*a*) $6\frac{3}{4}+\frac{4}{5}+\frac{7}{10}$; (*b*) $12\frac{3}{4}+16\frac{1}{2}+\frac{2}{3}$; (*c*) $7\frac{3}{8}+19\frac{4}{5}+\frac{14}{9}+\frac{4}{12}$.

10. Four coils of wire weighed $45\frac{1}{2}$ pounds, $47\frac{3}{4}$ pounds, $38\frac{7}{8}$ pounds, and $39\frac{1}{2}$ pounds, respectively. What was the total weight of the wire?

11. What is the total length of 3 pieces of cable $25\frac{3}{8}$ feet, $43\frac{1}{16}$ feet, and $29\frac{3}{4}$ feet long, respectively?

Third Lesson.

12. Subtract: (*a*) $\frac{3}{4}$ from $\frac{7}{9}$; (*b*) $\frac{13}{15}$ from $\frac{17}{19}$.

13. Subtract: (*a*) $\frac{3}{5}$ from $\frac{9}{10}$; (*b*) $\frac{7}{21}$ from $\frac{3}{7}$; (*c*) $\frac{13}{15}$ from $\frac{27}{25}$.

14. Solve: (*a*) $28-5\frac{1}{3}$; (*b*) $63-17\frac{2}{3}$; (*c*) $23\frac{1}{7}-15$.

15. Solve: (*a*) $12\frac{1}{6}-8\frac{5}{6}$; (*b*) $59\frac{4}{12}-40\frac{7}{9}$.

16. In a pump, the diameter of the steam cylinder is $18\frac{1}{2}$ inches and the diameter of the water cylinder is $10\frac{1}{4}$ inches. How much larger in diameter is the steam cylinder than the water cylinder?

17. Two pieces of iron, $5\frac{3}{4}$ inches and $6\frac{7}{8}$ inches long, respectively, are cut from a rod $24\frac{3}{8}$ inches long. How long is the remaining piece?

Fourth Lesson.

18. Find the product of: (*a*) $\frac{4}{5}\times\frac{6}{7}$; (*b*) $\frac{12}{13}\times\frac{5}{6}$

19. Multiply: (*a*) $\frac{6}{7}\times\frac{8}{9}\times\frac{3}{4}$; (*b*) $\frac{9}{10}\times\frac{16}{27}\times\frac{35}{45}$.

20. Multiply: (*a*) $7\times\frac{3}{5}$; (*b*) $15\times4\frac{1}{2}$; (*c*) $21\times\frac{13}{11}$.

21. Find the product of: (*a*) $12\frac{1}{2}\times8\frac{1}{3}$; (*b*) $13\frac{1}{5}\times\frac{7}{8}$.

22. What is the weight of $3\frac{2}{3}$ miles of copper wire if it weighs $6\frac{1}{4}$ pounds per 100 feet? There are 5280 feet in a mile.

23. What will be the cost of $85\frac{1}{2}$ feet of copper wire at $11\frac{1}{4}$ cents per foot?

Fifth Lesson.

24. Divide: (*a*) $\frac{5}{6}$ by $\frac{2}{3}$; (*b*) $\frac{84}{99}$ by $\frac{48}{77}$.

25. Divide: (*a*) $\frac{18}{25}$ by 36; (*b*) $26\frac{2}{3}$ by $\frac{2}{3}$.

26. Solve: (*a*) $10\div\frac{2}{5}$; (*b*) $100\div2\frac{6}{7}$; (*c*) $17\frac{1}{9}\div13$.

27. Solve: (*a*) $21\frac{3}{7}\div12\frac{8}{21}$; (*b*) $\left(\frac{45}{80}\div\frac{90}{112}\right)\div\left(\frac{27}{40}\times\frac{112}{135}\right)$.

28. If the circumference, or distance around the rim, of a locomotive driving wheel is $21\frac{2}{3}$ feet, how many revolutions will the wheel make in traveling 784 feet?

29. In a telegraph office there are 12 relays having the same kind of windings. The sum of their resistances is $480\frac{2}{3}$ ohms. What is the resistance of each?

The Railroad Electricians' Club

Meetings the 3rd Monday of Every Month, 8 P. M.—18th Floor Transportation Bldg., Harrison and Dearborn Sts., Chicago—Everybody Welcome—No Dues

Lead Storage Battery Questions

Prob. 14. What is the highest temperature at which it is safe to operate a lead battery?

Ans. 14. As stated by Mr. H. M. Beck, in his talk before the club in May, there is no definite voltage above which it may be said the battery is injured and below which it is not injured. High temperatures, in fact any temperature above normal (70 deg.) increases the tendency to form the white insoluble sulphate in the plates and the higher the temperature, the greater the tendency to sulphate. For this reason storage batteries should be carefully watched in the extremely warm weather in the summer time so that the plates may not become sulphated.

Batteries, of course, must operate at certain times of the year with the outside temperature at 100 deg. or even higher, and the charge or discharge current flowing through the battery further increases the temperature of the battery. Where it is possible to control the temperature at which the storage battery operates, this should be kept as near 70 deg. as possible and not be allowed to go higher than 90 deg.

Prob. 15. What is normal gravity?

Ans. 15. 1.220, when the battery is full charged. It should be remembered that charging drives the acid out of the plates and increases the gravity of the electrolyte.

Prob. 16. What are the safe limits for gravity of the the electrolyte?

Ans. 16. The electrolyte should not be less than 1.180 and not more than 1.250 when full charged in both cases. It is better to have the electrolyte too weak than to have it too strong. Acid should rarely, if ever, be added to the cells of a battery to bring up their gravity. If the gravity is abnormally low it will usually be found to be due to some trouble in the cell and that trouble should be removed by charging treatment instead of adding more acid, which may further increase the trouble.

Prob. 17. Why does temperature affect gravity? Is this of enough importance to be taken into consideration in practical work?

Ans. 17. We know that heat causes metal to expand and in the same way heat causes the electrolyte to expand. As it expands it becomes less dense and the gravity accordingly lowers. When the electrolyte cools off it contracts, condensing the molecules making up the liquid and so increases the gravity of the electrolyte.

Temperature must always be taken into consideration when making gravity readings. A change of 3 deg. in temperature will cause a change of one point in gravity. In other words, if a certain tank of electrolyte is at 1.220, with temperature at 70 deg., this same electrolyte will be at a gravity of 1.230 at 30 deg. less than normal temperature, which is 40 deg. Fahr. In the same way, this same normal gravity electrolyte will show a gravity of 1.210 if the temperature be raised to 30 deg. above normal (100 deg. Fahrenheit).

These facts show that gravity readings alone, unless the temperature is known, mean little or nothing. A cell might show normal gravity, 1.220, and indicate full state of charge, when, as a matter of fact, it might be only two-thirds charged, with a temperature of 10 above. This same battery would show a gravity of 1.200 had the temperature been 70 deg.

Prob. 18. I read gravity on a cell as 1,240 with the temperature 10 above zero Fahrenheit; is the gravity of the electrolyte above normal?

Ans. 18. 10 above zero is 60 deg. below normal temperature and since gravity changes one point with every 3 degrees, it will be (60 divided by 3 or) 20 points more than it would at normal temperature. Electrolyte showing 1.240 at 10 above zero would then show a gravity of 1.220 at normal temperature of 70 deg. fahrenheit. This gravity is about right, provided the cell is in a full state of charge when this reading is taken.

Prob. 19. Another battery shows gravity of 1,220 at 105 deg. Fahrenheit; is this gravity too high?

Ans. 19. 105 deg. Fahr. is 35 deg. above normal temperature of 70 deg., and since the gravity of the electrolyte decreases one point with every 3 deg. rise in temperature, the electrolyte at this temperature would show a gravity of 9 points lower than what it would at normal temperature. A gravity of 1.220 at 105 deg. would then be 1.229 at 70 deg. This is somewhat higher than should be used, particularly in warm weather. The gravity should be lowered by removing a small amount and adding water.

Prob. 20. In making up electrolyte for storage batteries how much acid and water do you put together?

Ans. 20. An electrolyte of 1.220 gravity can be made by pouring one volume of the pure concentrated acid, (gravity 1.84) into about 5 volumes of distilled water. Stir the mixture with a lead spoon or wooden stick, it will get very hot in the process of combining, so be sure to allow it to cool down to 80 or 90 deg. before putting this electrolyte into the storage cells.

Prob. 21. Do you pour the electrolyte into the water, or the water into the electrolyte? What difference does it make, and why?

Ans. 21. Always pour the acid into the water, never the water into the acid. There is a very strong chemical attraction between strong acid and water and they get hot when mixed. If the water is poured into the acid it will cause serious sputtering, like grease on a hot frying pan and this will be very apt to splash acid on the person mixing the electrolyte. *Always pour the acid into the water, never the water into the acid.* The reason for the sputtering occurring when water is poured into acid and not occurring when acid is poured into water, is that acid, being heavier than water, goes to the bottom and the combination takes place well below the surface where any boiling action would be prevented from causing trouble. Where water is poured into the acid it, being lighter than acid, would stay on the surface and the boiling action, due to the heat of chemical combination, would cause the mixture to sputter badly.

The principle of mass action also has a great influence and this is probably best explained by describing how soap is made. We all know that soap is a chemical combination of fat and lye. In order to make this combination, the lye is first heated up boiling hot and the grease is slowly poured into the lye. If the combination were made in the reverse order, that is the lye poured into the grease, it will be found that in the resulting soap there would be much uncombined lye and grease. In other words, the combination of grease and lye takes place more vigorously when the weak element, the grease, is put into the stronger element, the lye.

In mixing up electrolyte, of course, we want just the reverse action, that is, instead of trying to make the thing act vigorously we want to make the mixture with the least possible activity and heating, so we here put the stronger element, the acid, into the weaker element, the water, and the action takes place moderately.

Prob. 22. Why is it necessary to add water to all cells of the storage battery occasionally?

Ans. 22. When a storage battery is given its final overcharge, since the active material is now all converted into lead peroxide and lead sponge, the current passing through the battery simply breaks up the water in the electrolyte, forming the oxygen at the positive plate and hydrogen at the negative plate. This is known as "gasing" the battery. The gas given off, however, gradually uses up the water in the electrolyte and causes the surface of the electrolyte to lower gradually in service.

Water must be added occasionally to keep the electrolyte above the tops of the plates. It should be noted that the need for flushing the battery is then caused by gasing and the frequency of flushing periods indicates in a rough degree how much the battery is being overcharged. On some of the constant potential systems put into operation about a year ago it has been found that they do not need to flush the battery more frequently than once in every six months. This is because of the fact that with the constant potential method of charging the current at the end of the charge is very low and there is very little gasing.

Prob. 23. What damage will it do if the surface of the electrolyte is allowed to get below the tops of the plates?

Ans. 23. That part of the plate which projects above the level of the electrolyte will sulphate badly, forming a white insoluble sulphate which reduces the battery capacity and may seriously injure the plates. This should never be allowed to happen.

Prob. 24. Why do you add just water and not acid?

Ans. 24. In flushing the storage battery always add water, never acid or more electrolyte except possibly when the battery is given its annual capacity test at cleaning periods. In gasing, as explained in problem 22, only hydrogen and oxygen (decomposed water) are given off and water alone should be added. There is, of course, a very fine spray of acid which is carried off slowly on excessive gasing but this is so small that it will not affect the gravity to any degree and need not be taken into consideration.

Prob. 25. Will any kind of water do for flushing batteries?

Ans. 25. Filtered water is always the best thing to use in flushing a storage battery, although there are many locations where ordinary tap water is satisfactory. A sample of the water being used should be submitted occasionally to the battery manufacturer for test and approval. There are certain impurities which may not injure the storage battery, but there are others which very seriously injure. It must be remembered that even though the impurities contained in the water of a single flushing might not damage the battery, as the water is decomposed and boiled off in gasing the impurities are left behind, so that these impurities gradually accumulate in the battery and in time may injure the plates. Many roads use steam pipe line condensation; this is usually a very bad practice, as this water is apt to contain particles of iron rust and even a very small particle of iron impurity in the electrolyte will seriously damage the battery.

Prob. 26. What is the mud that collects in the bottom of battery tanks; is it cinders, dust, or lead formation?

Ans. 26. This "mud" is the active material which has been corroded off the plates, chiefly by gasing. It represents the life of the storage battery which has been exhausted in service.

Prob. 27. How thick can you let this mud collect before the battery requires cleaning?

Ans. 27. The battery must always be cleaned before this collection of mud in the bottom is allowed to reach the bottom of the plates as this will cause a metallic short circuit of the plates, which will discharge the battery and cause it to sulphate.

Prob. 28. How are you going to find out how thick the mud is?

Ans. 28. The only sure way to tell how deep the mud in a train lighting cell is, is to open the jar and remove the elements carefully so as not to stir up the sediment, then carefully pour off the electrolyte and the depth of mud can be directly observed.

Prob. 29. Is there any other way you can tell when a battery needs cleaning?

Ans. 29. If battery needs cleaning badly it will usually show trouble in losing its capacity on standing, developing short circuits between the plates, etc. Most roads have a regular cleaning period of from 12 to 18 months and all batteries are cleaned on this basis.

Problems for Next Month

Lead Battery Questions, Continued.

Prob. 30. What is the maximum safe current that can be taken from a 300 ampere hour standard car lighting battery?

Prob. 31. When you speak of a 300 ampere hour battery, does it mean it will give 100 amperes for three hours? (a) How long would a 300 ampere hour battery hold up voltage when discharged at a rate of 60 amperes? (b) How long would it hold up when discharged at the rate of 40 amperes? (c) How long would it hold up when discharged at 10 amperes?

Prob. 32. How can you tell when a battery has become completely discharged?

Prob. 33. When a car is received in the yards what tests should be made to see whether the battery is sufficiently charged or not?

Prob. 34. The open circuit voltage of a generator tells whether the generator is up to voltage or not, so when you measure the voltage of a battery with no discharge current flowing, why doesn't this give you an idea of the battery condition.

Prob. 35. How quickly can a 300 ampere hour standard car lighting battery be given a complete charge?

Prob. 36. What is the proper amount of current to give a 300 ampere hour battery on charging?

Prob. 37. What is the difference between charging a battery at constant current and charging it at constant potential?

Prob. 38. How can you tell when a storage battery is fully charged when it is, (a) charged at constant current, (b) charged at constant potential, (c) charged at constant current with taper charge at the finish.

Prob. 39. Why isn't the battery voltage at the end of charge reliable for stopping the charge?

Prob. 40. Why can't you use an automatic hydrometer for stopping the battery charge on an axle generator system.

Prob. 41. What are the advantages and disadvantages of a constant potential yard charging system?

Prob. 42. What are the advantages and disadvantages of a series yard charging system?

Prob. 43. What are the advantages and disadvantages of an individual circuit control yard charging system?

Prob. 44. What causes a battery to warm up when it is either charged or discharged?

Prob. 45. What is the highest temperature a battery should be operated at? What will happen if the temperature goes above that value?

Prob. 46. Why is it that a warm battery will charge at a lower rate and give a higher rate on discharge than a battery at normal temperature will?

Prob. 47. Why will a battery that is extremely cold, say around zero degrees F., require a charging voltage considerably higher and give a discharge voltage considerably lower than the same battery would at normal temperature?

Prob. 48. Can the electrolyte of a lead battery freeze? What happens if it does?

Prob. 49. What causes the specific gravity of a battery to rise as the battery becomes charged and to fall as the battery discharges?

Prob. 50. Why does it take a higher voltage to force 40 amperes through a car lighting battery at the end of charge than it does at the beginning?

Prob. 51. What causes a battery to gas, and why does it gas at the end of charge and not at the beginning?

Prob. 52. What causes a storage battery to explode sometimes when a light is brought near?

Prob. 53. Is it necessary to make a battery gas when charging it?

Prob. 54. Does excessive gasing of the battery injure the plates?

Prob. 55. Is it necessary to give a storage battery an overcharge occasionally?

A. B. C. Car Lighting Course

Edited by Edward Wray

The first lesson of this course was published in our Feb., 1912, issue. All back numbers covering over two years' work can be furnished, bound in heavy paper covers with special binding arrangement, so that future lessons can be added and preserved. This also includes all back lessons of the P. R. R. School of Electricity, the R. R. Electricians' Club, Prize Question Box, and Practical Stunts. Price $1.00. *(See blank on page* 6.)

Lesson No. 32

U. S. L. System with Ampere Hour Meter Control

The many advantages of the ampere hour meter principle of control in axle car lighting systems have been discussed in various articles and editorials in the RAILWAY ELECTRICAL ENGINEER for the past five years, so it is interesting now to consider the details of applying this principle to one of the car lighting systems which is in very extensive use. Several hundred of the U. S. L. type "C" equipments on Pullman cars are now being changed over in accordance with the wiring diagrams given in this lesson, so as to operate on the ampere hour meter principle of control for battery charging, instead of the battery voltage principle on which those equipments originally depended for terminating battery charge. This modified equipment, however, contains so many new features, both in its design and operation, that we will con-

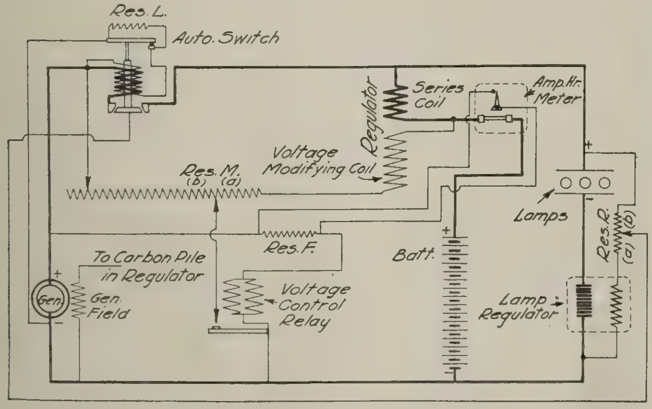
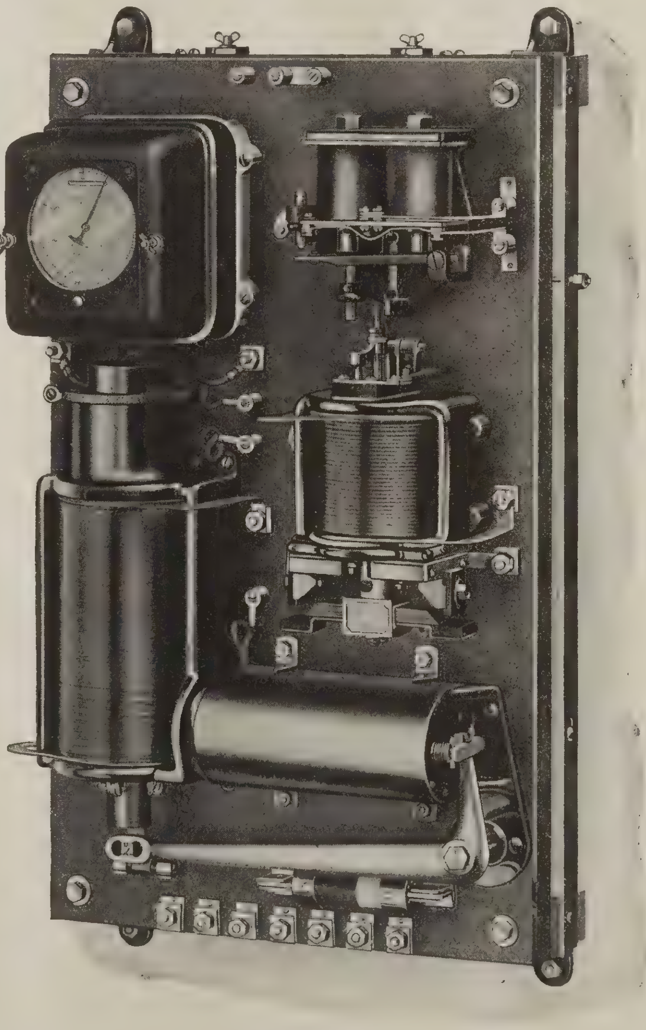


Fig. 173. Simplified Wiring Diagram of U. S. L. System.



U. S. L. Panel with Ampere Hour Meter for Controlling Charge Given Battery.

sider it as an entirely new equipment and attempt to describe it in detail.

Regulation of Generator.

There are here shown two separate diagrams of this equipment, Fig. 174, showing the location of wires, terminal posts and coils as they actually exist on the board, and Fig. 173, a simplified wiring diagram to show merely the principles on which this equipment operates. From either of the diagrams it will be seen that the regulation of the generator is effected by means of a compound regulating solenoid, made up of a series coil of heavy wire, through which all the battery current passes and a large winding of fine wire connected directly across the generator circuit; this latter is called the voltage modifying coil. Unless the contact in the voltage control relay is closed, however, this voltage modifying coil will be effective open when the equipment is operating, the entire magnetism of the solenoid must then be generated by the charging current flowing through the series coil. The weight of the plunger requires that a certain current, say 25 amperes, flow through the series coil, before it begins to regulate the generator by opening up the stack of carbons in the generator field circuit. There is an adjustable shunt provided across this coil, however, which makes it possible to increase the amount of current to battery by any desired amount. In other words, the current flowing into the battery when the generator is operating and when the battery is not in a full state of charge, will be the current through the regulating coil, say 25 amperes, plus whatever current that flows through the adjustable shunt, depenidng upon its setting.

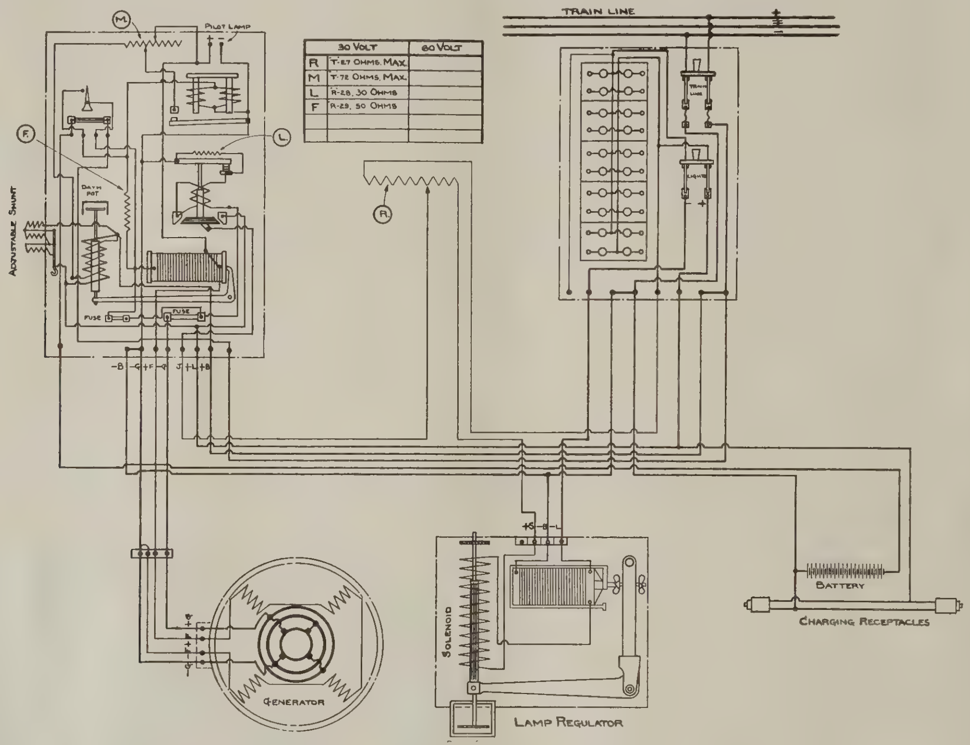


Fig. 174. Location and Connection of Wires, Terminal Posts and Coils.

When the equipment is at rest the current flowing from batteries to lamps will, of course, pass through this coil in a reverse direction, and if there were no current through the voltage coil at this time, this reverse current would generate magnetism which would lift the plunger and open up the stack of carbons in the field circuit, the generator might then be unable to pick up its voltage when leaving the station. In order to overcome this difficulty a contact is made from the resistance "M" in series with the modifying coil to the generator positive terminal, as shown in Fig. 173. When the generator is at rest its positive terminal becomes simply the negative terminal of the battery, as connection is then made from positive through the dead armature, which is of very low resistance, to battery negative. This allows current to flow through the voltage coil and this will create magnetism in the compound solenoid in the same direction as would normal charging current flowing through the series coil. When the car is at rest then, the magnetism of this voltage coil opposes the action of the magnetism of the reverse current through the series coil and prevents the plunger being lifted up by the lamp current.

Since the series coil of the regulator is in the battery circuit instead of the main generator circuit, the equipment will operate so as to keep the battery current constant, regardless of number of lamps in use. As lamps are turned on or off the total generator current is increased or decreased correspondingly.

Ampere Hour Meter Control.

An ampere hour meter is connected directly into the battery circuit and this records all of the battery charge and discharge in ampere hours, the meter hand moving in a clockwise direction upon discharge and in a reverse direction on charge. The meter runs 20% slower on charge than it does on discharge, however, as explained in our March lesson No. 26, so that by the time the hand gets back to zero all of the previous discharge, plus 20% to make up for battery losses, will have been put back into the battery.

When the dial hand gets back to zero then, it indicates that the battery is in a full state of charge and accordingly the charging current should be cut off or reduced to a low value. This is accomplished by means of a contact which is closed by the dial hand at the zero point of the meter, as shown in the accompanying diagrams. It will be noted that this contact simply short-circuits the resistance "F," which is in series with the coils of the voltage control relay. When this resistance is not short-circuited by the meter contacts, the current flowing from positive generator through this resistance to the voltage control relay will be so low that it will be unable to lift the magnet bar of the relay except on a generator voltage of above 48 volts such as would be experienced on open battery circuit. So long as the ampere hour meter shows the battery to be below full charge, the charging current will continue to flow even though it requires 45 or 46 volts as might be experienced in cold weather. The point at which the battery charging is discontinued, then, does not in any way depend upon the voltage of the battery.

When the resistance "F" is short circuited by the meter contacts, when the battery is fully charged, this places full generator voltage directly across the coils of the voltage control relay, and operates it immediately, closing the circuit from the voltage modifying coil to generator negative. This allows current to flow through the voltage modifying coil and this coil then generates sufficient magnetism to operate the regulator plunger without any aid from the series coil. In other words, the ampere turns of the voltage coil will simply replace a similar number of ampere turns in the series coil. Although the current through the voltage coil is very low, there are a great number of turns, in that coil, and the total ampere turns of magnetising force is about equal to that of the series coil. This magnetism then simply replaces the magnetism of the heavy current through the small number of turns in the series coil and the battery charging current flowing through that coil is accordingly reduced to a very low value. This will reduce the generator voltage to about 35 volts which is the average floating voltage of the battery. It cannot be said, however, that the charging current is entirely cut off since the battery circuit is not opened.

It is commonly understood that after the battery has become charged this type of combination voltage-current regulator maintains a certain constant potential, in fact, becomes a voltage regulator. This is not the case, however, for even with the battery fully charged and the voltage coil operating, the regulator still continues to be a current regulator; it might fairly be called a "zero current regulator," where the proper adjustment of the regulator windings is made.

After the ampere hour meter registers full charge and makes its zero contact the storage battery floats on the line, the generator then simply carrying the lamp load. On stopping at the next station the voltage control relay opens and if lamps are turned on, the battery will at once begin to discharge; the meter hand then moves away from the zero point and opens up its contact. When the car leaves that station the equipment will operate as a regular constant current machine until that battery discharge has been replaced and meter hand again gets back to zero, when it will again close contact and repeat the operation of the voltage control relay and voltage modifying coil as explained above.

New Lamp Regulator Feature.

As explained in previous lessons of this course the sole purpose of the small relay in the lamp voltage regulator circuit was to make this regulator more sensitive to voltage variation; it is not an essential part of the equipment. An ingenious method of obtaining a certain degree of this sensitiveness without the aid of an additional relay has been devised by Mr. C. C. Oberly, of the Pullman Company, and is made a part of this modified system.

As is well known, there is always a drop in battery voltage when the automatic switch opens and the load is thrown on the battery. In order to compensate for this drop in voltage, a fairly large resistance "R" is placed in the lamp regulator coil circuit. A lead, making contact with the tail piece of the automatic switch connects to this resistance "R," when the automatic switch is open, this lead will be dead and the full resistance "R" will be inserted in the circuit of the lamp regulator, cutting current through the coil down to low value. This will cause the carbons of the lamp regulator to be compressed solid together and reduce their resistance to a minimum, bringing nearly full battery voltage directly on the lamps. When the automatic switch closes, however, this lead connecting to the tail piece will then allow current to flow directly from positive generator to a middle point of this resistance and this will virtually short-circuit the section "B" of resistance "R." This will allow full current to flow through the lamp regulator coil, which will then lift its plunger if generator voltage goes above normal, and, opening the stack slightly, regulate the lamp voltage to normal. The lamp regulator then instead of being called upon to compensate for voltages varying from 28 to 45 volts, can be set much higher, compensating only for variations between 32 and 45 volts and its effectiveness and accuracy will be accordingly increased.

Error in Last Month's Lesson.

Clip out this diagram and paste it in last month's issue over similar diagram in Lesson No. 31.

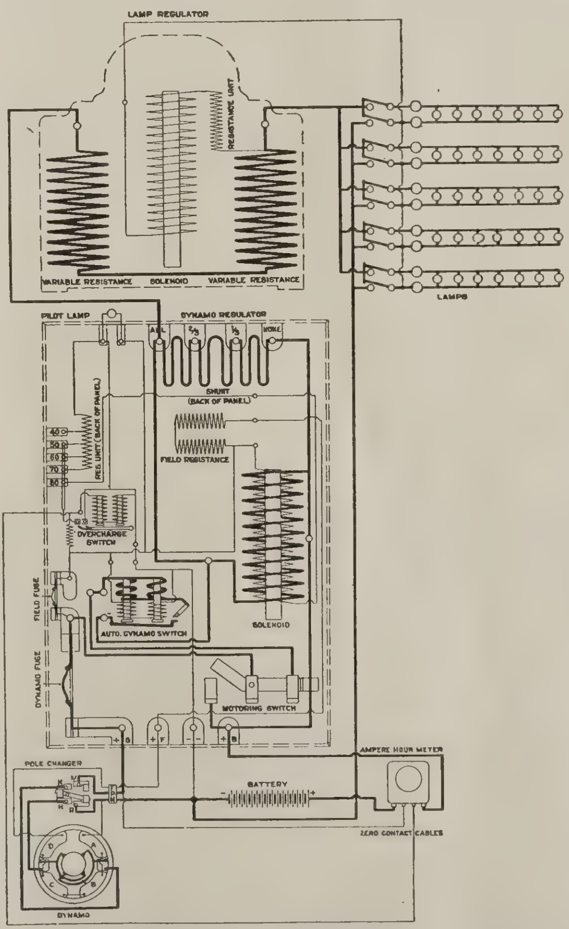


Fig. 171. Wiring Diagram of Consolidated Axle Equipment with Ampere Hour Meter Control.

Prize Question Box

This "Question Box" is open to every electrical man in the Mechanical, Signal and Telegraph, as well as Car Lighting Departments. We feel that this can be made a mighty valuable thing, so as a special inducement to the boys to boom it, we offer prizes for the best questions asked, as follows:

First prize	$1.00 *in cash*
Second prize	9 *months' subscription*
Third prize	6 *months' subscription*

There are some questions that are of a general nature, which should have comments of prominent men of experience. These will be published under "Questions Before the House," and we hope that prominent railroad men and manufacturers will discuss these questions. All answers published will be paid for at $1.00 *each.*

Questions Before the House

Generator Grounded Field Coil in Moskowitz.

No. 10—While motoring a Moskowitz generator, the automatic switch, after being closed, had a tendency to stick quite tightly in position and immediately release, in the same revolution of the armature. This effect was maintained as long as the switch was held in the operating position. In motoring this machine in the opposite direction, it was found to work perfectly. After carefully looking over the generator, it was observed that one field-coil was grounded. After removing the ground, the auto switch worked perfectly in either direction.

What caused the automatic switch to act in this manner? Why did the grounded field coil effect its operation only in one direction?—H. W. Millard, Santa Fe.

Axle Generator Troubles.

In motoring a type "A" Consolidated dynamo recently the dynamo would make an attempt to motor in the same direction immaterial of the position of the pole changer, and in each case the main fuse would blow. In connecting the generator afterwards, the positive and negative generator leads became reversed and the machine immediately started motoring with the auto switch closed and the main fuse out. Was this due to the generator being grounded? —G. B.

Ground on Type "K" Relay.

What effect will a ground on a type K relay have on the operation of the U. S. L. equipment?—Frank M. Burke, Pullman Co., Jersey City.

Scale on Battery Bridge.

Q. After a battery has been in service for 3 or 4 years and a plate breaks off from either group and you try to burn another plate on with an arc, I have found that a scaly hard substance is deposited on top of the bridge, which the arc will not penetrate, while on the under side of the bridge there is no such hard scale and an 8 volt arc will easily deliver 160 amperes. Why does this scale exist on the top of the bridge and not on the under side? What is it composed of, and what causes it to form?—E. J. Galloway, Oakland, Calif.

System of Handling Repairs to Axle Equipment.

No. 7. What is the best method of handling repairs to axle devices? That is, is it better to make repairs on each device enroute or at terminals as soon as the trouble develops or, by having a few spare equipments, simply replace the complete board or the complete generator which is giving trouble and make the necessary repairs in the shop?—L. S. Billau.

Ampere Hour Meters in Car Lighting Service.

What attention has it been found necessary to give ampere hour meters in car lighting service to maintain them properly? How frequently should they be removed from cars and taken into shop for thorough overhauling?—L. S. Billau, B. & O. Ry.

For the Axle Light Man to Think About.

No. 9—Some time ago one of our new coaches equipped with a Gould axle device with B. B. generator regulator arrived in Boston with a light failure. The field carbon pile was hot and the potential coil was warm. From appearances it looked like battery trouble. The battery was given a good charge and a discharge. On discharge it stood up to its rating, 300 ampere hours. The machine motored both ways and when speeded up the carbon pile being quickly compressed, the voltage generated by the revolving armature closed the automatic switch.

I rode the car on its next trip out to see how it would act under service conditions. Here is a log of test taken while enroute when train speed was approximately 20 miles per hour:

Automatic switch lifted until carbon contacts hardly came together; the lever arm, which is actuated by the potential coil, started to raise, releasing the pressure on field carbons; the meter registered 38 volts at 5 amperes. This condition remained the same even when train was going at high rate of speed. After waiting 15 or 20 minutes to see if there was any change, I pressed down very slightly on the lever arm and the automatic switch closed tightly and machine put up 50 amperes at 38 volts. After train came to a stop and started up again, the regulator worked the same way.

What caused the trouble?—Lester B. Knight, Boston & Albany R. R.

First Prize

An Interesting Case of Automatic Switch Trouble.

The cause for the failure of this equipment to deliver its rated output is readily traceable to the automatic switch itself. Here the defect will doubtless be found in the form of an excessively stiff spring between the bases of the two movable carbon contact fingers. This spring should be replaced by a much lighter one as soon as possible.

The explanation of the peculiar behavior of the apparatus is as follows:

At a train speed of about 18 or 20 m.p.h. the generator voltage is high enough to cause the lifting coil of the automatic switch to raise the movable cross-piece and thereby close the switch. But in this case since the carbon contacts are held too rigidly in position by the stiff spring, the normal pull of the lifting coil is insufficient to draw the cross-piece up far enough to establish the proper metallic connection between the two main brushes of the switch. Even the higher voltage resulting from increased train speed cannot strengthen the pull of the lifting coil enough to overcome the resistance of the spring, because of the fact that the potential regulation of the equipment prevents the voltage from exceeding a value of 38 volts in this particular instance.

Now it is evident that a generator potential, held down automatically to 38 volts, is incapable of forcing much more than 5 amperes through a circuit containing, in addition to the battery C.E.M.F., the comparatively high resistance of the two pairs of loosely touching carbon contacts. Consequently the ampere-turns, resulting from the flow of 5 amperes through the series coil of the switch, do not add enough to the pull of the lifting coil to produce any appreciable change in the position of the cross-piece. Moreover, this state of affairs will not be affected by an increase in train speed, for the obvious reason that the generator voltage is not permitted to rise further, as already stated, owing to the action of the potential coil.

But now, if the potential regulation is artificially manipulated so as to cause a momentary rise in the voltage of the system, the lifting coil the strength of which is dependent directly upon the impressed voltage at its terminals, will at once respond with a substantial increase in pull. The result is, of course, that the cross-piece is brought firmly into contact with the laminated brushes of the switch, and is held there until the train stops, but the combined strength the lifting coil and the series coil, since the latter now has the normal full load current of 50 amperes flowing through it. G. R. Fessenden.

No. 9. Assuming that switch works free, part of coil must be short circuited, which would weaken the pull. The pressure of the laminated copper brushes on the metal disk on top of the solenoid plunger would help to raise the switch until the lamp circuit is broken. The lamp load would then pass around the series coil, which would weaken the field circuit. The 38 volts would react on the potential coil, which would also increase the resistance in the field circuit and cause the carbon pile to become hot and also warm up the potential coil.

When he pressed down on the lever, he strengthened the field and raised the voltage, which closed the switch. Unsigned Communication.

No. 9. Referring to Question No. 9 in August issue, this trouble was no doubt due to extra resistance in lifting or shunt coil circuit of automatic switch, probably a poor connection or one of the leads on lifting coil being broken and only a few strands of the flexible wire forming circuit. The conditions in motoring and in road operation are different as to auto-switch cutting in. In motoring the armature is revolving at high speed and no load the resistance is cut out of field circuit instantly. This produces a high voltage and strong field and with a poor connection on lifting coil would probably close switch, whereas on the road the speed and also the voltage are built up gradually, and as this type regulator is a constant potential regulator, as soon as generator voltage reached 38 volts the potential coil operated to prevent further use in voltage. In motoring the voltage probably was as high as 60 or 70 volts and this closed auto switch before potential coil could operate.

Second Prize

A Problem for the Axle Light Man.

Assume we have a constant current regulator set for 40 amperes, 30 amperes lamp load turned on, and a carbon pile lamp regulator set for 31 volts, with the lamp regulator so designed that it would maintain this voltage even to the point of opening its own main stack of carbons. With the equipment operating under these conditions, what would happen if the battery circuit opens. L. D. Smith, Rock Island Lines, Chicago, Ill.

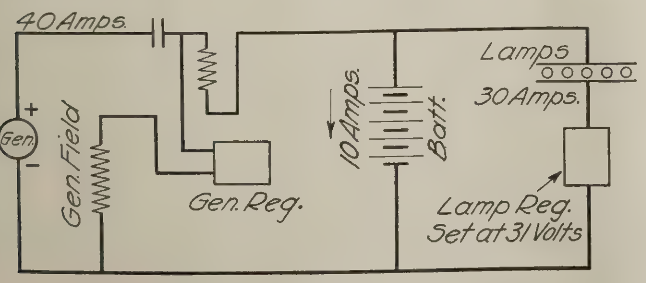


Diagram to Illustrate Axle Lighting Problem.

As the battery circuit opens, the 10 ampere current flowing to the battery will, of course, be discontinued. This will leave only 30 amperes generator current, all of which will flow to the lamps. Since the generator regulator is set for 40 amperes, the drop to 30 amperes will so weaken the magnetism of the regular solenoid that it will be no longer able to hold up the plunger. This will then drop and bring full pressure on the carbon pile, which will decrease its resistance and increase the current flowing through the generator field coils. The generator will then operate just as any stationary generator with a fixed field resistance would if the speed was varied over wide ranges, such as is found in axle generator service—its voltage will go up out of sight on high speed. The higher the generator voltage, the greater will be the field current, since there is no change in resistance of the carbon pile; and the greater the field current, the higher the voltage; the one will force the other up until the saturation point of the iron in the generator fields is reached and prevents further rise.

In other words, the generator voltage will increase and decrease as the train speed rises and falls. On an ordinary 30-volt machine this might go as high as 70 or 80 volts, or possibly higher at train speeds of 60 miles an hour. The fact that the generator is putting up 30 amperes lamp current in the meantime does not affect the generator voltage to any extent, except for armature reaction and voltage drop, due to resistance of the armature.

This problem assumes that we have a perfect lamp regulator, one which will maintain 31 volts across the lamps regardless of what voltage is developed by the generator. Under these conditions the current flowing through the lamps and lamp regulator carbons would never be more than 30 amperes and the difference between the standard lamp voltage of 31 volts, and the voltage developed by the generator, which might vary anywhere from 32 to 80 volts, will be absorbed by the resistance of the carbons in the lamp regulator circuit.

The generator regulator is now dead, since the current never gets up to its setting of 40 amperes, but the lamp regulator virtually becomes the generator regulator, since it controls the generator current to 30 amperes regardless of train speed.

This is, of course, a rather impossible condition, for there is probably no lamp regulator that has ever been constructed which would take care of such extreme conditions without straining the lamps.—E. W.

Third Prize

Water for Flushing Batteries.

No. 6. Why do battery manufacturing companies prescribe that only absolutely pure distilled water must be used for flushing the cells, when if pressed they will all admit that it is permissible to use Lake Michigan water? Is this water of equal purity with distilled water?—J. L. Ohmans, Elec. Fore., C. & W. I. Ry.

Distilled water is always preferred to any kind of tap water for flushing batteries. The reason for this is that most waters contain some impurities which might injure the batteries. It must be remembered that although one flushing might not injure the battery, the impurities are always left behind, for when the battery gases, only hydrogen and oxygen (the constituents of pure distilled water) are given off. Successive flushings then, each with its small amount of impurity, will gradually collect impurities in the battery to such a degree that it might eventually be injured. Lake Michigan water at Chicago, under present drainage conditions, will probably not injure a lead battery seriously. This is because it does not contain any harmful impurities, such as iron, common salt, etc. It is always advisable to submit to battery manufacturers occasional samples of tap water used for flushing.

Rise in Battery Voltage on Charge.

If the voltage of a battery on open circuit be a given amount, say 2.0 volts per cell, and charging current is sent into it, would the potential raise at the battery terminals be equal to the drop due to internal resistance of the battery?

It is well known that the voltage of a storage battery rises quickly as soon as it is placed on charge. This is due partly to the increase in the internal ohmic resistance of the battery and partly due to polarization, somewhat similar to that experienced with a dry cell on discharge (in both cases it opposes the flow of current). The ohmic resistance of the electrolyte is decreased slightly because of the fact that the acid in the plates is driven out of the active material into the electrolyte. This leaves a filament of active material on the surface, however, which is almost free from acid and there is accordingly a higher resistance at this point. These tend to compensate for each other. This, however, is not nearly as important a factor in the rise in voltage as is the chemical change within the battery produced by the flow of charging current. This latter causes the counter electro motive force of the battery to increase very rapidly at the start and continue to rise until near the end of charge, when gasing begins. The bubbles of gas greatly diminish the contact surface of the electrolyte with the plates and so increase the contact resistance with the active material at this point. This causes the abrupt rise in voltage at the end of charge, which is always experienced when gasing begins.—E. W.

A Question on Battery Flushing.

I have two sets of batteries running in same train and flush both on the same date. At the end of a period of thirty days I make inspection of both sets, and have usually found that one is down to top of plates, while the other is good for twelve days or more. Which set of batteries is in normal condition? The number of lamps and hours of service on both cars are the same. CBF Pullman Electrician.

This is not a question of either one of your batteries being in normal condition; they are doubtless both being seriously overcharged. As explained in previous issues, when a battery overcharges it gases and the gas given off is nothing but decomposed water. Therefore the amount of flushing necessary is an indication of how much that battery is being overcharged. When a battery is operated without excessive overcharging it should not require flushing more frequently than once in six months.—E. W.

Voltage of Edison Batteries.

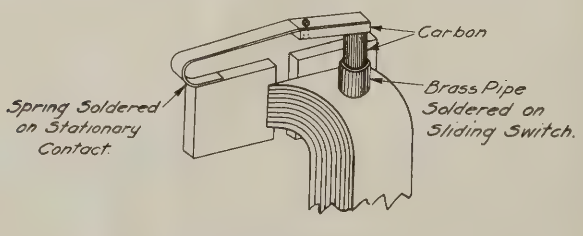
Is the voltage of the Edison battery affected by standing idle for a few days in extremely cold weather?—G. B.

If the weather was cold enough to completely freeze the battery (a very unusual occurrence) it would, of course, be unable to give sufficient voltage to light the car. We are advised, however, that with 30 of these batteries operating on one of the Canadian roads during the past winter, which was one of the coldest in history, there was no failure due to the effect of the low temperature. Another road operating out of Chicago advises that even though the voltage happens to be a little low at the start, due to the cold, the battery quickly warms up and furnishes normal voltage.—E. W.

Practical Stunts

We Pay a Dollar Apiece for Practical Stunts—Send in Your Ideas

Listen, electricians. Here is a secret. It is not a rare thing that a car is coming in yard from a journey of several miles, with the sliding contact hand switch (of Stone equipment) badly burned, and sometimes so badly that you have to change the sliding contact.


Carbon
Brass Pipe Soldered on Sliding Switch.
Spring Soldered on Stationary Contact

Home-made Carbon Brake Switch.

Very frequently the blame is laid on the car "porter." But sometimes due to the lack of lubrication on the movable center pins, the switch gets sticky so that even experienced persons anneal this sliding part of the switch by forming the arc too long between the contacts.

The attached cuts show a home-made carbon-break device which was put on a Stone switch and worked satisfactorily for some time.

A piece of ½-inch brass tube, ½ inch long, was soldered on to the end of the sliding contact, which holds a piece of arc-lamp carbon. A flat piece of carbon was riveted on a suitable brass spring which was soldered on the stationary contact and so adjusted that the sliding contact is broken before the carbon breaks the circuit.

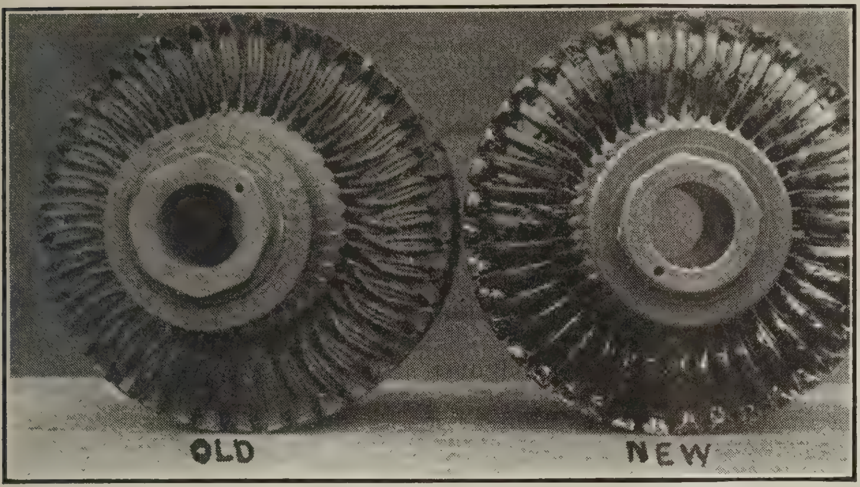
J. J. Keppel, Ontario, Canada.

Short Circuited Commutator.

When the mica insulation of the commutator has become burned so that it causes excessive arcing at the ends of the commutator segments a quick method of repair is to drill into the burned mica with a 1-16 in. drill, plug this hole with a wooden plug dipped in shellac; drill and plug a second hole beside the first, then a third, and so on, until all the burned mica has been re-placed by wooden plugs. If, however, the ground has been so severe that the mica has been entirely disintegrated, the burned space should be thoroughly cleaned out with a thin tool, such as an old hack saw blade ground to a convenient shape, and the cavity thus formed filled with a paste made of shellac and plaster paris.—C. B. Jennings, Santa Fe R. R., Topeka, Kan.

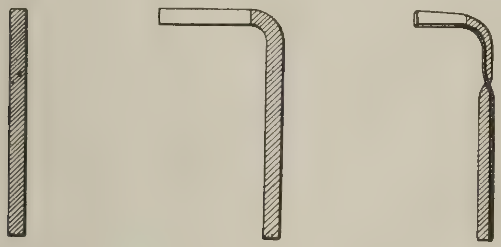
New Method of Rewinding Headlight Armatures

By Charles Barber, C.E., D. & R. G. R. R. Co., and A. H. Sherwood, Electrician, D. & R. G. R. R. Co.



Armatures Before and After Being Rewound with "Deltabeston" Ribbon Coils.

There has been a growing need for some method by which the opening and burning out of armatures could be overcome, also for a method of balancing the armature that would not prove injurious to the winding.



Method of Bending Flat Wire.

The armature on the right of the picture will give a good illustration of the method which has been devised by Charles Barber, chief electrician for the Denver & Rio Grande, and A. H. Sherwood, in charge of the winding department.

This armature is wound with flat "Deltabeston" wire, 25/1000 by 150/1000 in size, and is made in this special size for the Denver & Rio Grande by the D. & W. Fuse Company. It will be noticed that there is an air gap between each coil, which runs the entire length of the coil, as well as on the face of the armature, thereby causing a constant circulation of air through the winding, which enables this type of armature to run cooler than any other armature with the old style of winding.

The use of flat wire allows a better contact in the commutator segment, thereby preventing the heating and crystallization of the wire at that point, and does prevent the opening of the armature at the leads. It is impossible for the wire to rise out of the slots, as it is wound in flatwise.

The sketches show the method of bending the wire in order that the bottom lead will enter the slot in the commutator. It will be noticed that there are no sharp bends that would tend to break the wire or insulation, thereby causing an open or short circuit in the winding.

After the winding is completed the armature is dipped in a water, steam and oil proof plastic varnish; then baked for about twelve hours at 80 degrees Centigrade. The varnish used and the method of applying it make the armature impregnable to all weather conditions, as well as to the faulty conditions of stuffing boxes, etc., sometimes found on headlight turbines.

Balancing the Armature.

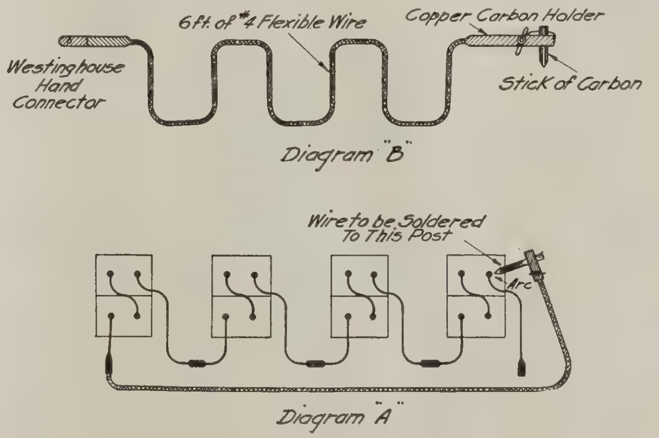
This is a very important part of the process of rewinding any armature. This type of armature is completely insulated and then accurately balanced by slipping sheet lead between the insulations and the laminations on the under side, the lead from old battery tanks being used for this purpose. It can be readily seen that this method has a big advantage over the old method of driving pins in the slots, which at times fly out, causing more or less damage, and in a good many cases short circuits and grounds in the winding.

Scenic Lines Employes' Magazine.

Emergency Welding.

Take a piece of No. 4 insulated wire six feet long and attach a female Westinghouse battery hand connector to one end, and a copper carbon holder to the other end. Then place a piece of stick carbon about four inches long in holder (see Diagram B). This combination can be used for repairing an open circuit in battery when the wire is broken off close to the terminal of the battery.

This connector is a practical time saver in a case of emergency, say when a car arrives at a terminal in a train in through service having a ten-minute layover, with an open in battery as above described. Instead of the present way of cutting out the entire crate, meaning a four-volt drop in battery, the wire could be permanently soldered to battery terminal in a very few minutes as follows:


6 ft. of #4 Flexible Wire
Copper Carbon Holder
Westinghouse Hand Connector
Stick of Carbon
Diagram "B"
Wire to be Soldered To This Post
Arc
Diagram "A"

Apparatus Used to Weld Post.

Pull crate with broken lead out on battery box door far enough to reach post the wire is to be attached to, then place connector to close circuit of three adjoining crates, arranging so carbon point will close circuit through post in which lead is to be soldered (see Diagram A), then by drawing an arc between point of carbon and post the lead can be readily

Removing Buckled Elements From Hard Rubber Jars

It is often found that the plates in car lighting batteries have become badly buckled or have grown and swelled considerably so as to make removal from the hard rubber jar difficult, if not impossible, without breaking the jar. This difficulty may be entirely overcome, however, if the electrolyte is removed and the jar with elements, placed in warm water for a few minutes until it softens somewhat. The jar will then usually come off of its own weight.

Since hard rubber jars are rather expensive, the slight amount of time and trouble taken to avoid accident in breakage by using this method is well warranted.

H. W. Millard, Santa Fe.

Test for Leaky Tanks.

Like many other roads, we used to test the lead linings of tanks for leaks by simply filling them with water and watching to see if the water leaked out.

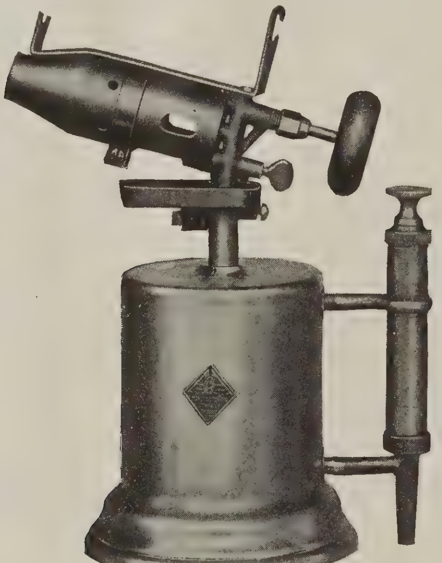
A much quicker and more convenient method is to clamp an air tight cover over the top of the tank, which is supplied with an air hose and valve; the tank is then immersed in water and the air turned on. A blow hole is left in the top of the cover which can be covered with the finger. In this way the pressure inside of the tank can be prevented from rising so high as to burst the tank.

Even the slightest pin hole in the tank will quickly show up by bubbles rising to the surface.—Jim Shutes, Rock Island.

With the Manufacturers

New Kerosene Torch

A new torch which seems to have solved the problem of using kerosene as a fuel for blow-torches is announced by Mr. W. M. Lalor, President of the A. & A. Mfg. Co.



Kerosine Torch.

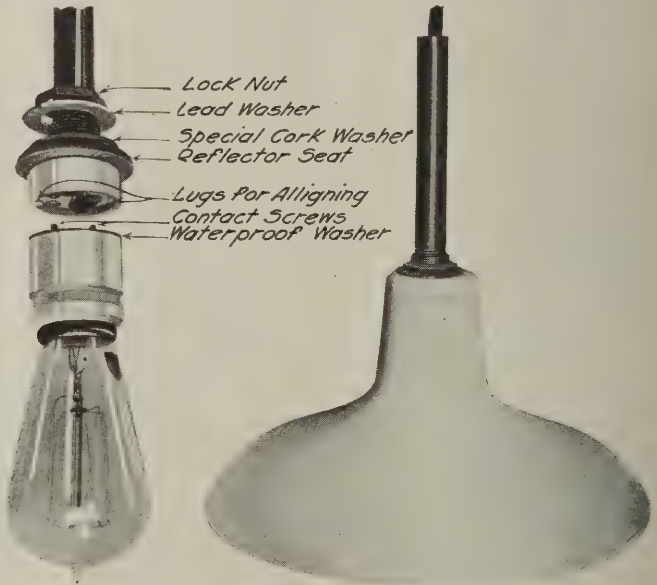
The torch shown in the accompanying cut has several novel features. The handle is large, well balanced, and easy to hold and a support under it permits of hand pumping without steadying the torch. The raw oil passes through a valve into one end of the two "U" tubes which are placed on either side of the burner where it is immediately vaporized. The gas coming from the other end of the tube is controlled by an adjusting nozzle which gives a more sensitive control of the flame than where an attempt is made to control the raw oil. A new cup construction under the burner enables the operator to start the torch quickly on kerosene.

Because of the high carbon content of kerosene, a much hotter flame is obtained than with other fuels with a saving in the quantity of fuel burned. The flame temperature is 2,200° F. as against 1,800° F. with gasoline used as a fuel. The construction of the burner prevents carbonizing of the kerosene.

It is also claimed for this torch, that the flame will not blow out even in the strongest wind.

New Type "R" Maxolite Fittings

A new fitting has recently been developed by the Central Electric Company, of Chicago, to accommodate various types of reflectors. This consists of a substantial malleable iron reflector seat with a neck at the top threaded both inside and out, the inside to receive conduit and outside to receive the lock nut as shown in the accompanying illustrations. The reflector is held solidly between a lead washer and the lock nut above and a special cork washer on top of the reflector seat below. A split porcelain socket is employed, the upper half, as shown in the figure being fastened to the reflector seat. Two porcelain lugs are cast in the upper half of the porcelain socket and these



Details of Maxolite Fitting.

fit into corresponding slots in the lower half of the socket and so align the two parts accurately.

Two long contact screws shown projecting above the lower half of the socket make connections both electrically and mechanically between the two parts of the socket. The lamp base shell is so constructed as to prevent these screws from falling out and being lost when the socket is being installed overhead. A thin rubber gasket between the two parts of the porcelain socket makes this waterproof and where desired an additional rubber gasket at the lamp base can be added as shown in the illustration. This protects all metal parts of the socket from both water and acid fumes such as might be experienced in roundhouses.

These fittings make it a comparatively simple matter to install reflectors as there are so few parts to the fitting, and these so conveniently arranged. With the lead gasket on the top and the rubber gasket below these fittings become entirely water and vapor proof and the cork gasket acts as a cushion to prevent the enamel from cracking with vibration or jar. This waterproof feature is important and should recommend this fitting for railroad service. These fittings will accommodate all the standard types of reflectors up to 1,000 watts. With lamp larger than 150 watts a mogul base socket is supplied.

One of the Eight Gas Electric Cars Used on the St. L.-S. W. R. R.

In addition to simplifying the installation of reflectors the method of wiring is made a feature in that it saves time and allows for a ready access to the socket.

With this fitting it is also possible to raise the reflector on a stem after fixture has been hung and make new wiring connections or change sockets.

Gas Electric Motor Cars for the St. L. S-W. R. R.

The St. Louis Southwestern Railway, St. Louis, Mo., has commenced to place in operation the first lot of eight gas-electric motor cars that are now being received from the General Electric Company. At this writing four cars, No.'s 10, 11, 12 and 13, have been shipped, two of which are in commission.

Car No. 10 is now making the trip between Shreveport, La., and Lewisville, Ark., a distance of 62 miles. Along the route are ten regular stops, seven flag stops and four railroad crossings. The time required for the run is 2 hours and 30 minutes. The car, however, makes one trip each way per day, totalling 124 miles.

In the formation of the St. Louis Southwestern Railway are included the Pine Bluff Arkansas River Railway, the St. Louis Southwestern Railway of Texas and the Eastern Texas Railroad. It is known as the "Cotton Belt Route" and has a total mileage of 1,810 miles. Starting at St. Louis, Mo., it follows a southwesterly direction across Arkansas into Texas. Here at Mount Pleasant one branch terminates at Ft. Worth and the other runs through Waco to Comanche and to Stephenville. Numerous lines of the road connect with important centers like Cairo, Ill., Memphis, Tenn., Little Rock, Ark., and Dallas, Texas. The equipment of the road comprises 242 locomotives, 235 passenger cars, and 12,445 freight and miscellaneous cars.

All the gas-electric motor cars for this railway company are what is known as type RE-70-B-11. The details of construction conform in general to those of the standard cars manufactured by the General Electric Company. The specific dimensions of the St. Louis Southwestern cars are 70 ft. 1⅜ in. over bumpers by 10 ft. 6⅜ in. wide over all. They weigh approximately 49 tons, have a seating capacity for 62 passengers, two per seat, and are each equipped with two GE-205, 600-volt, box frame, oil-lubricated, commutating pole railway motors having a total of 200 h. p. capacity. The motors are mountd with nose suspension directly on the axles of the forward truck. The generating unit consists of an 8-cylinder, 4-cycle gas engine of the "V" type, direct-connected to a 600-volt, commutating pole electric generator, designed to meet the special conditions the service demands.

The interior of the cars is partitioned into four compartments. The cab in front containing the power plant apparatus measures 11 ft. 11 in. long; next is the baggage room, 10 ft. 11⅞ in. long; then the smoking section, 12 ft. 5 in. long, and the passenger compartment, 30 ft. 5⅞ in. long. The track is standard gauge.

The body of the cars is of all-steel construction, except the seats and interior finish, which is of mahogany. Rear platform entrances are provided. The bearings and treads and flanges of the wheels conform to MCB standards. The trucks are of the heavy spring bolster type with elliptic bolster and coil equalizer springs.

Electric Arc Welding

This is the title of a new bulletin recently issued by the Westinghouse Elec. & Mfg. Co., and contains some very interesting information on this subject. Various types of arc welding, in use both in the past and present, are described and the welding equipment, motor, generator, controlling apparatus, carbon and metallic electrodes, flux, etc., are fully described. Full instructions for welding are given and also some interesting data on voltage across the arc with varying lengths of arc from 2 to 6 in. A comparison of the blacksmith versus arc welding rings, shows that with the section 1x1½ in. the costs are about equal, but with a section of 2x6 in. the costs are $3.05 for the smith weld and 85c for the arc weld.

Copy of bulletin will be sent upon request to the Westinghouse Elec. & Mfg. Co., Pittsburgh.

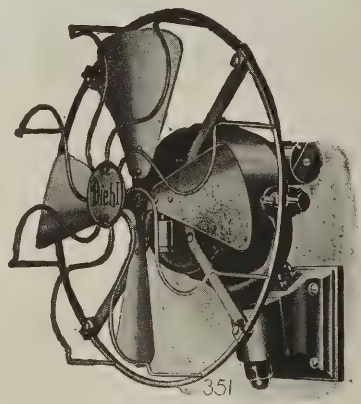
DE VEAU

OKONITE
TRADE MARK
REG. U.S. PAT. OFFICE

TRADE
BROOKFIELD
MARK

The House

Our ability to make immediate shipment from an immense
to railroad orders. Your entire requisition for electrical
one order and you receive the goods in one shipment. Think



Diehl Car Fans, pleasing in design, give a finishing touch to passenger comfort. They have been designed especially to meet the severe conditions of railroad service. The fan body is readily removed from the base without disturbing the wiring. Furnished in all standard voltages and also 30-60 volt combination. In ordering specify voltage.

DELTABESTON WIRE
REG. U.S. PAT. OFF.

"Deltabeston" Magnet Wire

is used by many roads for rewinding fields and armatures of

Electric Headlights

The insulation is pure asbestos fibre, impregnated.

It won't burn out.

Neither is it affected by moisture.

Can be supplied in all sizes; either flat or round.

Central Elect

320-326 S. Fifth Ave. "The House

BRYANT
SUPERIOR WIRING DEVICES

COLUMBIA
MAZDA

FWEW

TRADE
Pittsburg
MARK

Invincible
CLEANERS

MYRLITE

Central Electric Company Chicago OKONITE

ALEXALITE

BANNER

# of Service

stock of the best electrical equipment ensures prompt attention equipment on any job, no matter how large, can be covered with of the convenience! Let the *"House of Service"* serve you.

Diehl

OKONITE

TRADE MARK.

Insulated wire for railway signals, car lighting, shop and terminal light and power service must be absolutely dependable and have the highest insulating qualities — this is just another way of specifying Okonite. It has for years been the standard in railway service.

Okonite Insulation contains never less than 30% of the best quality dry, fine, up-river Para rubber and is made in but one grade, only—**The Best.**

It is generally conceded that the diffused light reflected from the north sky is the most satisfactory for the illumination of buildings. Therefore, all architects in placing skylights for the illumination of buildings give them the north exposure, to cut off the glaring direct rays of the sun.

Alexalites are so designed as to cut off the intense direct rays of the Mazda and Nitrogen Mazda Lamps. THEY DO IT!

PERKINS

ric Company

of Service"

Chicago

FARADAY

QUALITY

TRADE MARK HEMINGRAY REGISTERED

EVEREADY

Obituary.

Mr. Thomas E. Hughes, manager of the Philadelphia office of the Standard Underground Cable Company, died at his residence, Atlantic City, N. J., August 27th, funeral services being held in Philadelphia on Monday, August 31st. Mr. Hughes had long represented the Standard Company throughout its Atlantic Coast territory from Philadelphia south, and for the past seventeen years had been Manager of its Eastern and Southeastern Branch Office Sales Department located at Philadelphia.

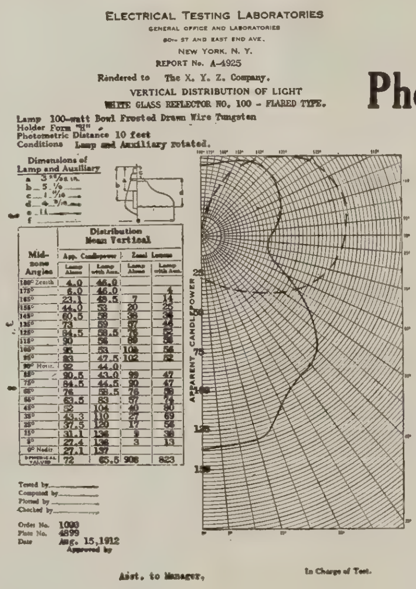
New Induction-Motor Regulator.

The Allen-Bradley Co., of Milwaukee, have developed a new speed regulator for polyphase slip-ring induction motors, operating light machine tools requiring one-fourth to ten h.p. This regulator is of the carbon compression type. The carbon discs are enclosed in insulated steel tubes. The resistance is changed by varying the pressure on these discs.

By turning a hand wheel the speed may be changed and an infinite adjustment may be obtained between maximum and a 50% speed reduction. This flexibility of control will find practical application in many cases where accurate adjustment of speed is required.

Mudge & Co. Make New Ventilator.

Mudge & Company, of Chicago, who have for a period of several years been an authority on passenger car ventilation, are now manufacturing and selling their own ventilator which is known by the trade name—Mudge-Peerless. Attractive folders illustrating and describing this device are now ready for mailing to those interested.


Dimensions of Lamp and Auxiliary
a 3 11/32 in.
b 5 1/8
c 1 11/16
d 4 3/16
e 11
f
Apparent Candlepower
25
50
75
100
125
150

ELECTRICAL TESTING LABORATORIES
GENERAL OFFICE AND LABORATORIES
80TH ST AND EAST END AVE.
NEW YORK, N. Y.
REPORT No. A-4925
Rendered to The X. Y. Z. Company.
VERTICAL DISTRIBUTION OF LIGHT
WHITE GLASS REFLECTOR NO. 100 - FLARED TYPE.

Lamp 100-watt Bowl Frosted Drawn Wire Tungsten
Holder Form "H"
Photometric Distance 10 feet
Conditions Lamp and Auxiliary rotated.

Mid-zone Angles	Distribution Mean Vertical			
	App. Candlepower		Zonal Lumens	
	Lamp Alone	Lamp with Aux.	Lamp Alone	Lamp with Aux.
180° Zenith	4.0	46.0		
175°	6.0	46.0		4
165°	23.1	49.5	7	14
155°	44.0	53	20	25
145°	60.5	58	38	38
135°	73	59	57	45
125°	84.5	58.5	75	52
115°	90	56	89	58
105°	95	53	104	56
95°	93	47.5	102	52
90° Horiz.	92	44.0		
85°	90.5	43.0	99	47
75°	84.5	44.5	90	47
65°	76	58.5	76	59
55°	63.5	83	57	74
45°	52	104	40	80
35°	43.3	110	27	69
25°	37.5	120	17	56
15°	31.1	136	9	36
5°	27.4	138	3	13
0° Nadir	27.1	137		
Spherical Values	72	65.5	908	823

Tested by
Computed by
Plotted by
Checked by

Order No. 1000
Plate No. 4899
Date Aug. 15, 1912
Approved by

Asst. to Manager, In Charge of Test.

The Photometric Curve

has become necessary for all illuminating engineering computations.

In order to make our services more valuable, a new photometric sheet has recently been designed for use in tests of this character, which presents not only the polar co-ordinate curve, but also the engineering data which makes the sheet complete for all engineering calculations.

Copies of a specimen report will be sent upon application.

Electrical Testing Laboratories
80th Street and East End Avenue
NEW YORK

Committees of the Association of Railway Electrical Engineers

Semi-Annual Convention will be held at Atlantic City, Friday, June 12th, Headquarters Hotel Dennis. Annual Convention October 26th to 30th, at Chicago.

PRESIDENT

C. R. Gilman, C., M. & St. P. Ry.

SENIOR VICE-PRESIDENT

H. C. Meloy, L. S. & M. S. Ry.

JUNIOR VICE-PRESIDENT

E. W. Jansen, Ill. Cent. Ry.

SECRETARY-TREASURER

Jos. A. Andreucetti, C. & N. W. Ry.

EXECUTIVE COMMITTEE

C. J. Causland, Penn. R. R. Lines East.
L. S. Billau, B. & O. R. R.
Wm. A. Del Mar, N. Y. Central.
J. E. Gardner, C. B. & Q.
J. J. Hack, So. Pac. Co.

COMMITTEE ON AXLE EQUIPMENT.

H. R. Bucks, Chairman, Chief Elec., Oregon Short Line.
R. T. Smith, Elec. Eng., Gt. West. Ry., England.
E. M. Cutting, Edison Storage Battery Co.

COMMITTEE ON DATA AND INFORMATION.

B. F. Bilsland, General Electric Co.
C. J. Causland, Pennsylvania R. R.
George W. Cravens, Cravens Electric Company.
W. A. Del Mar, Asst. Elec. Engr., N. Y. C. Line.
A. J. Farrelly, C. & N. W. Ry. Co.
J. E. Gardner, C. B. & Q. R. R.
W. M. Wiggins, Elec. Insp. Pullman Co
Edward Wray, Chairman, *Railway Electrical Engineer.*

COMMITTEE ON ELECTRIC TRACTION

H. M. Van Gelder, Chairman, Westinghouse, Church, Kerr & Co.
J. H. Davis, Elec. Engr., B. & O. R. R.
D. C. Woodbury, N. Y. C. & H. R. R. R.
Paul Real, Ass't Engr., N. Y., N. H. & H. R. R.
Chas. P. Kahler, Elec. Engr., Oregon Short Line R. R.
C. B. Keiser, M. M., Penna. Lines East.

COMMITTEE ON ELECTRIC HEAD LIGHTS.

Chas. R. Sugg, Chairman, Elec. Eng., Atlantic Coast Line R. R.
Geo. E. Murrey, Chief Elec., Chicago Shops, C. & N. W. R. R.
J. J. Hack, Eng. Tr. Ltg., H. & V. Southern Pacific R. R.
Jno. E. Gardner, Elec. Eng., C., B. & Q. R. R.
L. C. Hensel, Chief Elec., St. Louis & San Francisco R. R.

COMMITTEE ON HEAD END EQUIPMENT

K. R. Hare, Chairman, Chief Electrician, N. P. R. R.
Jos. A. Andreucetti, General Foreman, C. & N. W. Ry.
C. R. Gilman, Chief Electrician, C., M. & St. P. Ry.
J. J. Hack, Engineer Train Lighting, Heating and Ventilating, S. P. R. R.

COMMITTEE ON ILLUMINATION

L. S. Billau, Chairman, Elect. Dept., B. & O. R. R.
J. L. Minick, Chief Draftsman, Penna. R. R.
H. C. Meloy, Chief Elect., L. S. & M. S. R. R.
L. Schepmoes, Safety Car Heating & Lighting Co.
D. P. Morrison, Elec. Engr., P. & L. E. R. R.
W. H. Rolinson, Westinghouse Lamp Co.
Preston S. Millar, Electrical Testing Laboratories.
C. W. Bender, National Elec. Lamp Association.

Sub-committee on Lamp Specifications.

J. L. Minick, Chairman,
J. R. Sloan,
Henry Rogers.

COMMITTEE ON INDUSTRIAL TRUCKS.

T. V. Buckwalter, Chairman, Penn. R. R.
C. E. F. Ahlm, Chief Engr. The Elwell-Parker Elec. Co.
H. G. Thompson, Vice-Pres. The Edison Storage Battery Co.
J. E. Hale, Experimental Engr. The Goodyear Tire & Rubber Co.
F. K. Fildes, Elec. Dept. Penn. R. R.
H. A. Currie, Ass't Elec. Engr. N. Y. C. & H. R. R. R.
A. H. Gfrorer, Mech. Eng., C. W. Hunt Co.

COMMITTEE ON LOOSE LEAF BINDERS FOR FILING SPECIFICATIONS AND TO KEEP SPECIFICATIONS AND STANDARDS TO DATE

J. R. Sloan, Chairman, Eng. Elec. Tr. Ltg., Penna. R. R.
J. L. Minick, Chief Draftsman, Penna. R. R.
T. V. Buckwalter, Draftsman, Penna. R. R.

COMMITTEE ON OUTSIDE CONSTRUCTION AND YARD LIGHTING

H. M. Warren, Chairman, Elec. Engr., D., L. & W. R. R.
W. H. Keirn, Elect., Penna. R. R.
Jos. A. Andreucetti, Gen'l Fore., C. & N. W. R. R.
C. J. Causland, Chief Elect., Penna. R. R. Lines West.
C. D. Axtell, Gen'l Fore., D., L. & W. R. R.
J. L. Minick, Penna., R. R.

COMMITTEE ON RECIPROCAL RELATIONS

L. S. Billau, Chairman, Elec. Dept., B. & O. R. R.
J. R. Sloan, Eng. Elec. Tr. Ltg., Penna. R. R.
Jos. A. Andreucetti, C. & N. W. R. R.

COMMITTEE ON SHOP PRACTICE

Geo. W. Cravens, Chairman, Manager Welding Apparatus Deparment, C. & C. Elec. & Mfg. Co.
R. F. Moon, Westinghouse Electric & Mfg. Co.
G. M. Crownover, Supt. M. P., Chicago-Great Western Ry.
L. C. Hensel, Chief Elec., St. Louis & San Francisco Ry.

RAILWAY
ELECTRICAL ENGINEER

Official Journal
of the Association of Railway Electrical Engineers.

PUBLISHED MONTHLY BY

WRAY PUBLISHING CO.

C. D. SPERRY,
Assoc. Editor.

EDWARD WRAY,
President.

ADVERTISING BLDG.—123 W. MADISON ST.
CHICAGO.
Telephone, Randolph 7414.

Entered as second-class matter, August 6, 1909, at the Post Office at Chicago, Ill., under the Act of March 3, 1879.

TERMS OF SUBSCRIPTION

United States, Canada and Mexico - - - Per Year, $1.00
Foreign - - - - - - - - - - Per Year, $1.50

Table of Contents

Page

Editorial:

Seventh Annual Convention A. R. E. E.............133
Standardization of Motor Sizes for Traveling Cranes.133
Committee on Axle Equipment 134
Committee on Data and Information..................139
Committee on Electric Headlights 144
Committee on Head End Equipment 145
Committee on Engineering Manual and Loose Leaf Binders 148
Committee on Illumination 149
Committee on Industrial Trucks 151
Committee on Standards 152
Committee on Outside Construction and Yard Lighting..153
Committee on Reciprocal Relations 160
Committee on Wire Crossing Specification 160
Committee on Standard Rules for Car Wiring and Specification for Electrical Equipment 161
Committee on Wire and Cable Specifications...........163
Committee on Standardization of Train Lighting Lamps.171
Committee on Yard Facilities for Charging Storage Batteries 171
Committee on Electric Traction 175

A. B. C. Car Lighting Course:

Brown Boveri (German) System 181
Prize Question Box 182
The Railroad Electricians' Club 184
Practical Stunts 187
Association Directory 189

STATEMENT OF THE OWNERSHIP AND MANAGEMENT, required by Postal Authorities, of *Railway Electrical Engineer*, published monthly, at Chicago, Ill., required by the Act of August 24, 1912.

Editor...C. D. Sperry, Chicago
Publisher ....Edward Wray, Chicago
Business Manager ....None
Owner ....Wray Publishing Co., Chicago
Stockholders holding 1 per cent or more of total stock............ Edward Wray, Chicago

Known bondholders, mortgagees and other security holders, holding 1 per cent or more of total amount of bonds, mortgages or other securities, none.

(Signed) Edward Wray, Publisher.

Sworn to and subscribed before me this 14th day of October,
Edward J. Schumacher,
Notary Public, Chicago, Ill.
(My commission expires April 8, 1917.)

The Seventh Annual Convention A. R. E. E.

Although not of a meteoric nature, the development of the Association of Railway Electrical Engineers during the past seven years has been rapid, effective, and consistent. Starting with an organization of a mere handful of men, whose interests were chiefly electric car lighting, the association soon expanded into one which concerned itself with all applications of electricity for light and power in railroad service.

It is now generally conceded that the electrification of main line divisions of railroads is, in many cases, justified purely on a basis of economies effected. This will, without doubt, cause the electrification of many divisions of main line track during the next few years; in fact, we already see the hand writing in the electrifications in the Bluefield division of the Norfolk & Western, the Deer Lodge division of the C. M. & St. P. Ry., and in the plans of the Pennyslvania R. R.

With the working out of this plan, electricity will play a far more important part in the operation of steam railroads than ever before. Railroad men, who are to be the leaders of the future must be thoroughly familiar with electrical machinery and equipment. This offers opportunity of wonderful possibilities to the Association of Railway Electrical Engineers for development and service. It is gratifying to see how effectively the association has met the issue in the first report of its Committee on Electric Traction.

Let this committee be continued and be made one of the standing committees of the association; probably no other committee has such an opportunity for service to the association and to railroad men generally as does this committee.

Standardization of Motor Sizes for Travelling Cranes

The report of the committee on Data and Information as published in another part of this issue, brings to light a very chaotic condition which exists in the matter of motor sizes for operating shop traveling cranes. This, in some cases, showing a variation of from 1 to 15 in the size of motors for the same function on cranes of the same capacity.

One of the first principles in railroad operation, after "Safety First," is standardization, and through a consistent adherence to this principle, marked economies are effected in all departments of the railroads.

It seems, however, that in the matter of motor sizes for traveling cranes, the principle of standardization has been entirely forgotten. This is evidenced by the fact that on one of the largest railroads in the country we find eleven different combinations of motor sizes for a certain size crane, ten different combinations for another size crane, etc.

There is, of course, justification for a certain variation in motor sizes as all cranes are not called upon to work at the same speed. The size of motor depends both on the weight of the load to be lifted or transported, and also on the speed at which this is to be handled. It should be possible, however, to establish three standard speeds for operating cranes: slow, moderate and high speeds. Having established these standard speeds, it would be a more or less simple matter to standardize on motor sizes corresponding to these speeds for the various sizes of cranes.

The situation is not quite as simple as it might appear on first thought, however, for motor manufacturers have not yet standardized among themselves on motor frame sizes, and since the frame size selected for a certain motor largely controls the motor h. p. rating, this might cause the size of motor supplied by a certain manufacturer to vary slightly from that of another.

It is hoped that a special committee on this subject may succeed in bringing the various manufacturing and railroad interests to a common ground, with the result that we may have suitable standards for motor sizes, base mountings, etc. This will result in a marked economy both for manufacturers and railroads and will greatly reduce the maintenance cost and store house supply necessary for crane motors.

Seventh Annual Convention A. R. E. E.

October 26-30, Hotel La Salle, Chicago

Reports of Committees

Committee on Axle Equipment

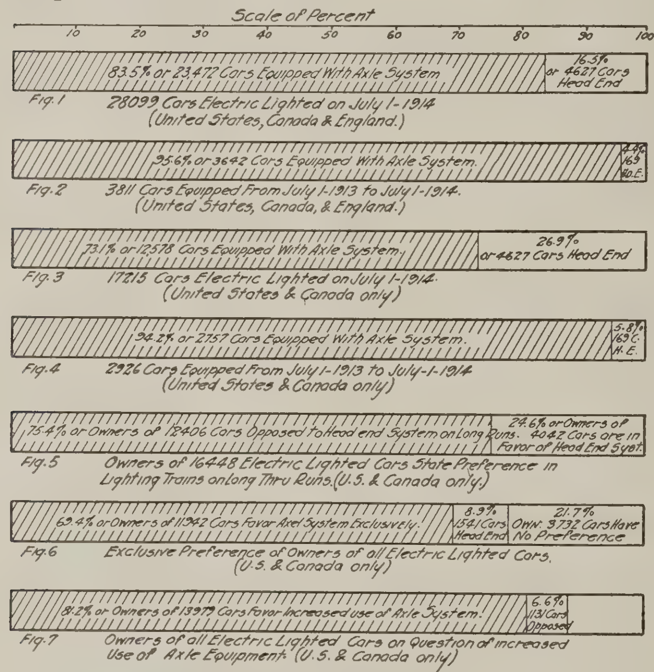
Your committee was instructed to report the development of Axle Equipment and the general tendency of railroads toward Axle Lighting in preference to other systems.

Axle vs. Head-End Systems.

Table I tabulates data furnished either by the man directly in charge of train lighting or the Superintendent of Motive Power.

Figures 1 to 6 show graphically the preference of railroads for Axle system as compared to Head End.

You will note from the data submitted that almost without exception roads operating in the north-west quarter of the United States favor Head End system for **"long runs on through trains."**



Graphic Representation of Preference of Roads for Axle vs. Head-End Systems

Of this group of roads the owners of 16.3% of all electric lighted cars owned by them qualify their opinion as being held "at present," and the owners of 18.4% of the cars so owned really favor Head End Axle system, leaving the owners of but 65.3% of the electric lighted cars in this group who favor Head End system for this character of work in a true sense. Of this remainder a little more than half, or the owners of 37.4% of the cars, favor neither Head End nor Axle system exclusively, but are in favor of the increased use of Axle system.

Therefore in this group, which owns 4,042 cars, the owners of 27.9% of these cars, or but little over one thousand electric lighted cars, are truly loyal to what is commonly understood as the Head End System.

A large factor in this situation and perhaps the main reason for such an "insidious influence" in the ranks of Head End advocates is the fact that in most of the Head End lighted trains operating in the northwest quarter of the United States an increasingly large percentage of Axle plant cars is being operated, which, of course, increases the cost per car of maintaining the Head End cars and lessens the reason for the very existence of that system.

To complete the comparison in a geographical sense, the owners of practically all cars in the eastern half (with the exception of a very small number of roads) and the southwestern quarter of the United States, the owners of Pullman cars (making up a large percentage of all trains on long runs in the entire United States) and the owners of all cars in Canada and England favor the Axle system exclusively for train lighting.

We wish to call attention to the fact that all cars reported as equipped for Head End system, with the exception of dynamo cars, or approximately 93% of all Head End cars, may be converted without loss into Axle lit cars.

Some roads ostensibly favorable to the Head End system have all new cars equipped with regulator lockers and battery boxes.

Axle Car Lighting Costs in England.

Below we give curves showing the cost to maintain axle equipments on Railroad "G" see Table III, p, 136 and tabulated statement of such costs on Railroad "F" (in U. S. A.) followed by a summary of costs per car per month and per 1,000 car miles on all roads which were kind enough to furnish such information.

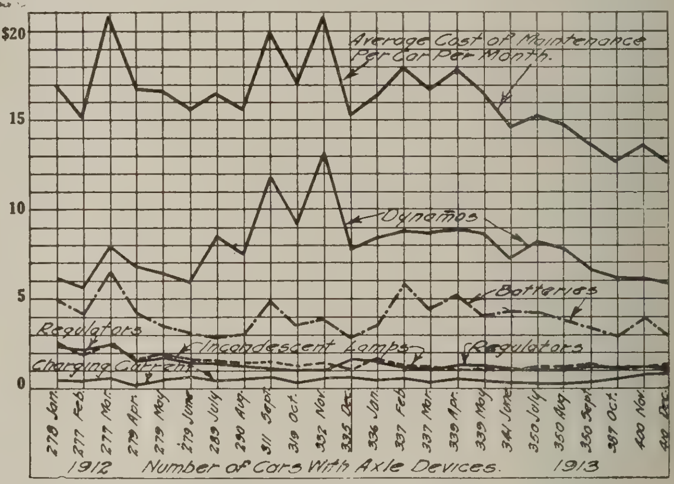


Fig. 8. Detail of Costs for Railroad "g." See Table III

Attention is called to the high cost of maintaining dynamos as compared to all other portions of the equipment.

This item is worthy of the particular attention of the manufacturers among whom a feeling seems to exist that the generator is in need of no improvement.

Battery maintenance seems to be little more than half that of dynamo.

It is hoped that the entire question of maintenance costs may be generally discussed on the convention floor.

It has been suggested that it is unfair to compare operating costs per car in England with those in this country because there is a smaller number of lighting fixtures in the English coach and less current used for lighting than in the American.

It has also been suggested that the method of recording costs per car month is less reliable than that of cost per one thousand car miles.

Attention is called to the 28-day period used by Mr. Smith in reporting English cost of maintenance, obviously for the purpose of equalizing the length of periods per annum.

Batteries used for lighting at all times, the double set per car and generator used only for charging the batteries results in a much greater percentage of total car maintenance being charged to batteries in England than in the United States.

Information as to division of maintenance costs between labor and material, rates of pay to men engaged in this work

TABLE I.

	Number of Cars Equipped on July 1st, 1914.		Number of Cars Equipped during Year 1913-1914.		Favor Head End, Long Through Trains.	Favor Axle System, Exclusively.	Favor Head End System Exclusively.	Favor Increased use of Axle System.	Number Axle Generators with Ball Bearings.	Number Cars Equipped with Edison Batteries.
	With Axle Plants	Head End	With Axle Plants	Head End						
ROADS IN ENGLAND										
Caledonian Ry	347	0	33	0	No	No	No	...	88	0
Great Central Ry	580	0	50	0	No	Yes	No	...	150	0
Great Eastern Ry	341	0	0	0	No	Yes	No	...	1	0
Great Northern Ry	307	0	12	0	No	Yes	No	...	0	0
Great Western Ry	676	0	110	0	No	Yes	No	...	406	0
London & Nor. Western Ry	2360	0	217	0	No	Yes	No	...	2360	0
London & So. Western Ry	1595	0	15	0	No	Yes	No	...	50	0
London Brighton & So. Coast Ry.	816	0	87	0	No	Yes	No	...	78	0
Midland Ry	738	0	38	0	No	Yes	No	...	74	0
North British Ry	267	0	28	0	No	Yes	No	...	53	0
North Eastern Ry	451	0	74	0	No	Yes	No	...	70	0
So. East. & Chatham Ry	2406	0	221	0	No	Yes	No	...	80	0
ROADS IN CANADA										
Canadian Northern	96	0	78	0	No	Yes	No	Yes	96	0
Canadian Pacific	387	0	107	0	No	Yes	No	Yes	387	39
Grand Trunk	39	0	9	0	No	Yes	No	Yes	24	1
Grand Trunk Pacific	72	0	42	0	No	Yes	No	Yes	72	0
Intercolonial	11	0	5	0	No	Yes	No	Yes	0	0
ROADS IN U. S. A.										
Atch. Topeka and Santa Fe	478	0	62	0	No	Yes	No	Yes	96	1
Atlantic Coast Lines	45	0	25	0	No	...	...	...	8	23
Baltimore and Ohio	114	45	68	0	...	...	...	Yes	50	45
Boston and Albany	69	0	37	0	No	Yes	No	Yes	34	0
Boston and Maine	11	0	11	0	No	Yes	No	...	6	0
Buff., Roch. and Pitts	48	0	27	0	...	Yes	No	Yes	0	0
Central of Georgia	22	0	14	0	No	Yes	No	Yes	0	19
Cent. R. R. of New Jersey	22	0	22	0	...	...	...	...	0	0
Chesapeake and Ohio	163	0	22	0	No	Yes	No	Yes	2	0
Chicago and Alton	30	0	8		No	Yes	No	Yes	7	0
Chicago & East'n Illinois	68	0	2	0	No	Yes	No	Yes	1	0
Chicago and Northwestern	79	215	26	8	Yes	No	No	Yes	20	2
Chicago, Burl. & Quincy	6	742	0	40	Yes	No	Yes	Yes	3	0
Chicago, Great Western	82	0	7	0	No	Yes	No	Yes	14	38
Chicago, Mil. & St. Paul	10	982	4	56	Yes	No	No	Yes	4	0
Chicago, Rock Island & Pacific	411	0	75	0	No	Yes	No	Yes	178	5
Chicago, St. Paul, Minn. & Omaha	5	60	2	2	Yes	No	No	Yes	0	0
Cincinnati, Hamilton & Dayton	17	0	0	0	No	Yes	No	Yes	0	0
Cleveland, Cin., Chic. & St. Louis	161	0	59	0	No	Yes	No	Yes	111	0
Delaware & Hudson	4	1	0	0	No	Yes	No	Yes	0	0
Delaware, Lacka. & Western	46	0	22	0	No	Yes	No	Yes	19	0
Denver & Rio Grande	47	4	0	0	Yes	No	No	Yes	0	0
Erie	72	0	2	0	No	No	No	No	1	0
Great Northern	29	629	24	0	Yes	No	No	...	28	0
Illinois Central	259	0	33	0	No	Yes	No	Yes	6	158
Kansas City Southern	3	0	0	0	...	Yes	...	...	3	0
Lake Shore & Mich. So.	213	0	94	0	No	Yes	No	Yes	83	2
Lehigh Valley	384	0	133	0	...	Yes	...	Yes	165	5
Long Island	126	0	20	0	No	No	No	Yes	0	0
Louisville & Nashville	108	0	15	0	No	Yes	No	Yes	20	25
Maine Central	6	0	0	0	No	Yes	No	...	4	3
Michigan Central	150	0	100	0	...	Yes	...	Yes	85	0
Minneapolis & St. Louis	17	0	0	0	No	Yes	No	Yes	0	0
Minn., St. Paul & S. Ste. M	126	0	62	0	No	Yes	No	Yes	13	0
Missouri, Kansas & Texas	23	0	9	0	No	Yes	No	Yes	...	...
Missouri Pacific	70	0	0	0	No	Yes	No	Yes	...	1
Mobile & Ohio	18	0	0	0	No	Yes	No	Yes	14	0
Morgan's La. & Texas	63	0	41	0	No	Yes	No	Yes	41	5
Nashville, Chatt. & St. L	15	0	10	0	No	Yes	No	Yes	0	10
New York Cent. & Hud. River	1007	0	331	0	No	Yes	No	Yes	429	2
New York, Chi. & St. Louis	10	0	10	0	No	Yes	No	Yes	9	0
N. Y., New Haven & Hartford	400	0	173	0	No	Yes	No	Yes	35	35
N. Y., Ontario & Western	13	0	12	0	No	Yes	No	Yes	12	12
Norfolk & Southern	11	0	9	0	No	Yes	...	Yes	0	11
Norfolk & Western	83	0	64	0	...	...	...	...	22	71
Northern Pacific	14	725	1	0	Yes	No	Yes	Yes	3	0
Oregon Short Line	15	97	13	0	Yes	No	No	Yes	14	18
Ore. Wash. R. R. & Nav	6	174	1	33	...	...	...	...	...	...
Pennsylvania	293	0	34	0	No	No	No	...	183	16
Pere Marquette	111	0	11	0	No	Yes	No	Yes	1	0
Philadelphia & Reading	73	0	71	0	No	Yes	No	Yes	0	0
Pullman	5400	400	634	0	...	Yes	...	Yes	628	0
Pitts. & Lake Erie	33	0	32	0	No	Yes	No	Yes	32	0
Rutland	5	0	5	0	No	Yes	No	Yes	5	0
St. Louis & San Francisco	236	0	0	0	No	Yes	No	Yes	14	0
St. Louis & Southwestern	10	0	0	0	No	Yes	No	Yes	7	0
San Pedro, Los A. & Salt Lake	5	31	0	0	...	...	...	...	...	...
Seaboard Air Line	75	0	16	0	No	Yes	...	Yes	21	23
Southern	258	0	35	0	...	...	...	Yes	...	2
Southern Pacific	112	220	25	0	No	Yes	No	Yes	26	21
Spokane, Portland & Seattle	1	53	0	0	Yes	No	Yes	No	0	0
Texas & Pacific	14	....	....	....	...	...	...	...	...	1
Union Pacific	20	237	0	30	Yes	No	...	No	1	1
Vandalia	10	0	0	0	...	...	...	...	0	0
Wabash	41	12	3	0	No	Yes	No	Yes	0	0
Western Maryland	27	0	0	0	No	Yes	No	Yes	27	
Western Pacific	72	0	0	0	Yes	Yes	...	Yes	0	
Wheeling & Lake Erie	3	0	0	0	No	Yes	No	Yes	3	
Grand Rapids & Indiana	5	0	0	0	...	...	...	...	...	...
Colorado & Southern	0	0	0	0	Yes	No	No	Yes	0	
Atlantic Coast Line	0	0	0	0	...	...	...	...	...	...
Northwestern Pacific	0	0	0	0	...	...	...	...	...	...
San Antonio & Aransas Pass	0	0	0	0	...	...	...	...	...	...
Total	**23472**	**4627**	**3642**	**169**					**6477**	**598**

and lighting units and illumination values provided in car lighting in England has been requested and is expected in time for the discussion of this report at the convention.

Table IV, page 137 is neither complete nor exhaustive. There are other companies doing a certain amount of electric train lighting business, but Messrs. J. Stone & Co. have furnished so many more equipments than all the other companies put together, that beyond the four companies cited much of the business is still experimental. Many of the railway companies object very strongly to the extra capital cost involved in electric train lighting as compared with oil-gas lighting with inverted mantles, and in general only new stock is being lighted electrically, and that is not being done on all the railways. At the present time some 14 per cent of British passenger rolling stock is electrically lit, all by axle systems.

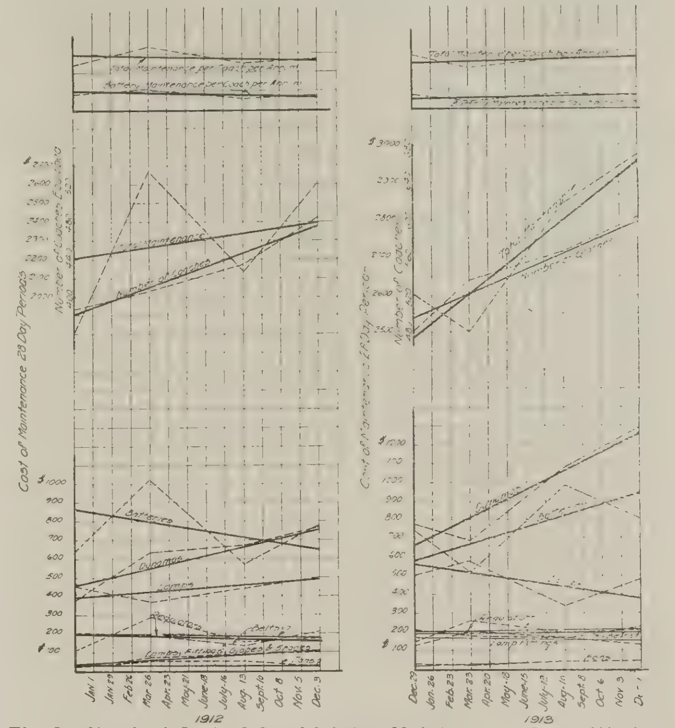


Fig. 9. Itemized Cost of Car Lighting Maintenance, Great Western Ry. (England)

Axle Equipment in England.

The type of storage battery used varies with the different systems. Invariably (with one or two isolated exceptions) twelve-cell lead secondary batteries are used, varying in capacity from 120 ampere hours to 400 ampere hours. Some systems make the capacity of their batteries (rated on a 9-hour discharge) suitable for discharging the lamp load for 5 hours, others for 10 hours, depending largely on whether the equipment is for a fast non-stopping or a slow stopping service. Messrs. J. Stone & Co.'s system involves two batteries, one being charged while the other is discharging in parallel with the lamps and the batteries are (in the latest type of change-over switch) interchanged at every stop. Their system tends to overcharge the battery on long daylight runs, and in consequence they supply a partially formed pasted plate with a very heavy grid, allowing planté formation to go on steadily during the life of the cell. A life of from 5 to 7 years per positive plate is secured by this means. Generally the other systems employ a planté formed positive, which should have vertical ribs to ensure that all growth is in a vertical and not in a horizontal direction. The negative is usually of the box type, the paste being entirely boxed in by perforated lead sheets. Treated wood separators between plates of opposite polarity is usual but not universal practice.

Batteries of this type are made by the Tudor Accumulator Co.; the Chloride Electrical Storage Co., Ltd., (who chiefly sell their "Lux" type plates); the D. P. Battery Co.; the Leitner Electrical Co.; the Bart Accumulator Co., and Messrs. Pritchetts & Gold. No doubt there are experimental instances of the use of the Jungner or the Edison Alkaline Accumulator, but at the present time their price is prohibitive.

With few exceptions, the capacity of the train lighting positive plate is uniformly 30 ampere hours (at the 9-hour rate) without being actually standardized, and cells are made up with 3, 5, 7, 9 and 11 such positive plates with the corresponding negatives, to give the required capacity. The plates are lead burned to a bar carrying the terminal lug. The Great

Western Railway, and at least one other British Railway, are now using glass boxes for the plates, long experiment having shown that on their road and with the class of traffic handled glass boxes do not get broken in service.

The equipment and maintenance of electric train lighting plant in Great Britain is, with about two exceptions, in the hands of Locomotive, Carriage and Wagon Superintendent (often his title is Mechanical Engineer). If there is a Carriage and Wagon Superintendent responsible to his directors independently of the Locomotive Chief, he equips and maintains. This has resulted in very little variety in types of equipment, and the great difficulties in electric train lighting have had to be overcome by the contractors rather than by the railway.

On the railway where the maintenance of electric train lighting is carried out by the mechanical engineer its care is only one of the maintenance duties and forms a special item in the carriage examining staff's work. It is very difficult in such a case to get the time of any but the specialists properly allocated to the work. On a railway where the maintenance of electric train lighting is in the hands of the electrical engineer (as in the case of the writer's company, the Great Western Railway) the maintenance is carried out by a staff entirely separate from the carriage examining staff, though the latter by arrangement do a certain amount of definitely specified work. On the Great Western the 3,000 miles of route is divided up into 7 districts (which do not correspond with other departments' districts or divisions), each with a depot with not less than one electrical examiner and in general an assistant at each. These men may travel with failures all over their districts. Each depot holds complete spares (dynamos, regulators, cells, belts, as opposed to spare parts). There are two electrical fitters stationed at two of these depots, one controlling the northern and the other the southern division, and they are called in to change all parts required to be connected up to wiring, the examiner only changing such parts as do not require connecting up electrically.

The head depot is at London and is now being built. At this depot all batteries for new equipments (plates, glass boxes, wood separators, electrolyte and connectors being bought separately and assembled) are charged and installed, the rest of the equipment being mounted on the coach by the carriage department at the locomotive, carriage and wagon works at Swindon under the supervision of an electrical inspector. At the head depot complete dynamo and regulator testing plant is installed for the accurate measurement of power input to the axle pulley belt throughout the range of speed. Sufficient machine tools are installed for the complete repair and partial renewal of equipments. The depot is in charge of an assistant under whom the chief inspector works, and the principle of maintenance is that while complete dynamos, cells, belts, regulators, fuses, lamps, etc., can be exchanged on the road by examiners and fitters all failed parts are sent to London for repair at the head depot. The company's stores and purchasing department have a branch in the London train lighting depot and all stores are booked out direct to the train lighting staff.

Machinery exists for reporting failures through the traffic department the district locomotive superintendent and the electrical examiners to the electrical engineer, so that a failure, whether inconvenient to traffic or not, rarely escapes notice. Forms for the reporting of failures are arranged for tracing its cause and recording when it is put right on card indexes, and the failures, all changes in equipment, battery renewals, battery washing out, belt renewals and other data are circulated every 28 days. Quarterly meetings of the maintenance assistant, chief inspector, inspector of new work and the electrical fitters are held to confer on all maintenance matters. Every electrically lit coach is represented by a numbered tag on a board, the tags being colored to show if the batteries have been or have to be overhauled. Exclusive of one assistant, one chief inspector and one clerk, each 22 coaches require a man (inspectors, fitters, chief examiners, assistant examiners, battery men and laborers) to maintain them and the cost of this maintenance is shown in Fig. 9. The cost is too high, owing to the fact that the new depot is incomplete and until the stores department is established there complete parts booked out but not used have to be charged against the maintenance.

The Committee requested additional information on some

TABLE III

SUMMARY OF MAINTENANCE COSTS

Railroad	Miles Per Light Failure	Number Cars Operated	COST Per Car Month	COST Per 1000 Car Miles
"A"	529007	215	$18.88	$1.94
"B"	......	96	15.66	......
"C"	285114	478	11.20	......
"D"	......	126	* 8.79	......
"E"	......	40	8.61	......
"F"	......	166	9.76	1.62
"G"	......	96	28.00	......
"H"	......	356	15.17	......
Average (U. S. A.)	407061	197	14.51	1.78
Great Britain	......	600	¶ 5.88	......

*Figure probably does not include heavy shop repairs.

¶£1.21 x $4.86 equals $5.88.

TABLE II

RAILROAD "F" U. S. A.

MAINTENANCE OF AXLE LIGHT EQUIPMENT FOR YEAR ENDING DECEMBER 31st, 1913

RECAPITULATION All Equipments		ROAD MAINTENANCE			SHOP MAINTENANCE			TOTAL MAINTENANCE		Total Cost per 1000 Car Miles
				Cost per 1000 Car Miles			Cost per 1000 Car Miles			
Generators	Generator	$1123.59			$467.99			$1591.58		
	Suspension	99.73			14.04			113.77		
	Regulator	186.10			93.20			279.30		
	Oil	110.53			.82			111.35		
	Belt & Details	1651.54			75.57			1727.11		
	Total		3171.49	.2648		651.62	.0544		3823.11	.3192
Battery	Material	544.80			1332.07			1876.87		
	Charging Current	330.39						330.39		
	Total		875.19	.0731		1332.07	.1112		2207.26	.1843
Labor	Inspection	5750.11			63.77			5813.88		
	Maintenance	2614.97			2458.79			5073.76		
	Total		8365.08	.6985		2522.56			10887.64	.9092
TOTAL DIRECT CHARGE			$12411.76	$1.0364		$4506.25	$0.3763		$16918.01	$1.4127
Lamp Renewals:			1995.83			162.92			2158.75	
Fuses Wire Fixtures Sockets Shades	Miscellaneous		309.18			488.05			797.23	
		Credit	55.00		Credit	369.11		Credit	424.11	
GRAND TOTAL			**$14661.77**	**$1.2243**		**$4788.11**	**$0.3998**		**$19449.88**	**$1.624**

MILEAGE BY CLASSES OF EQUIPMENTS;

	Miles
U. S. Light & Heating Co.	669,919
Consolidated Ry. El. & E. Co.	3,722,220
Gould Coupler Co.	4,909,826
Safety Car Htg. & Ltg. Co.	2,673,634
	11,975,599

MILEAGE BY CLASSES OF CARS:

	Miles
12 Buffet Cars	1,284,728
3 Cafe Cars	377,240
8 Business Cars	293,993
21 Dining Cars	2,520,688
10 Smoking Cars	1,003,080
22 Coaches	1,652,286
20 Mail Cars	2,791,395
22 Storage Mail Cars	789,059
5 Pass. & Bagg. Cars	377,517
6 Horse Cars	263,372
37 Baggage Cars	622,241
Total 166 Cars.	11,975,599

of the later developments of English equipment but as one of the companies expressed it "we shall be obliged if you will kindly allow this matter to remain in abeyance until things settle down again."

An effort was also made to secure information from German companies but naturally without success.

We expected to confine our remarks on development prior to the past year to the summaries but we found the narratives of development so interesting that we decided to incorporate them at greater length.

TABLE IV

Notes on the Development of Some of the Most Used Axle Systems of Electric Train Lighting in Great Britain.

	Messrs. J. Stone & Co.	Messrs. The Leitner Electric Co.	Messrs Vickers, Ltd.
(1) Approximate number of equipments in use in British Isles, July 1, 1914	18,000*	900	450
(2) Date when development work started...	1890	1902	
(3) Date when system first placed on market	1894	1902	1904
(4) Dates of any important changes in design	Changes in detail but not in principle have been made continuously.	Single armature in place of double armature machine in 1905.	Improvements made from time to time as circumstances required.
(5) Any important developments or improvements between July 1, 1913, and July 1, 1914	Constant speed or variable speed "Liliput" machine developed.	Elimination of external regulator in 1914.	
(6) Type of storage battery used with system. Type of plates. Method securing active material..........	"Tonum" battery with rolled lead grids and pasted plates for both electrodes.	Planté positive with undercut grid. Non-shrinking pasted negative.	Planté type positives in lead lined teak boxes.

*Messrs. Stone & Co. have upwards of 70,000 coaches equipped on 250 railways all over the world.

Messrs. Mather & Platt, Ltd., promised particulars but were not received.

Storage Battery Development

Gould Storage Battery Co.

Development commenced 1896
First placed on market..........................1898
Changes in Design—

No change has been made in the formation of the plates or their characteristics. Only minor changes have been made, in for instance, dimensions, shape of lugs, etc.

Latest development is the double stoneware tank and antimony-lead alloy cover.

United States Lighting and Heating Co. ("National").

First Placed on Market..........................1901
Changes in Design—

Faure or pasted plates prior to **1901.**
1901—Plante plates (both positive and negative).
1904—"Unit" type of positive plate (Faure negative).
1907—"Swedged" unit substituted for the cast unit.
1908—One-piece Plante-Positive and Plante-Negative plates.
Recently supplied pasted plates for certain railroads desiring them for experiment.

Electric Storage Battery Co.

Development Commenced 1887
First Placed on Market..........................1888
Changes in Design—

Prior to **1894** an alliance was formed with the three largest battery manufacturers in England, Germany and France.
1894—The Company had taken steps toward the acquisition of basic battery patents and the patent rights of a number of smaller companies.
1895—The Manchester positive plate was placed on the market (patent rights secured from the English Company).
1900—The Exide battery for vehicle service put on the market.
1901—Box Negative secured from the German Company.
1906—The Shelf Negative plate placed on the market.
1907—The Tudor Positive secured from the German Company.
1910—Purchased patent rights of Westinghouse Storage Battery Company.
1911—The Ironclad Exide Battery brought out (vehicle).

Edison Storage Battery Co.

Development Commenced 1891
First Placed on Market..........................1904
Changes in Design—

1904—Type "E" Battery placed on the market and withdrawn the same year.
1908—Type "A" Battery placed on the market.
1909—Type "B" Battery placed on the market.

Willard Storage Battery Co.

Development Commenced 1891
First Placed on Market..........................1895
Changes in Design—

Both Positive and Negative plates are now and have been from the beginning of Plante's formation. Secret process of formation of plates, the proper adjustment of weight of lead, core and leaf are factors determined by their experience. No noteworthy changes until the recent "NO WASH" battery was brought out.

Development of Axle Lighting Systems

The Electric Storage Battery Company. Axle Equipment.

This equipment involves special features quite different from those of any other such apparatus on the market in that it is a constant voltage rather than a constant current system, the voltage of the dynamo being fixed independently of the current delivered to the battery and lamps. This voltage is fixed slightly above the floating voltage of the battery, but not sufficiently high to permit any injurious overcharging. Owing to the narrow range of voltage variation no lamp regulator is required. The dynamo is of the Rosenberg reaction type which develops the same polarity for either direction of rotation without any pole changing apparatus. The field control consists of a Wheatstone bridge made up of resistances having special temperature characteristics which produce a constant dynamo voltage for all speeds above the cut-in speed regardless of the dynamo output.

Gould Coupler Company.

The present system was an outgrowth and development of previous systems which extended over quite a period of years. Development has gradually eliminated counter machine control and substituted therefor carbon pile generator control as embodied in the present "Simplex" system. This carbon pile regulation development had been taken up by this company in 1908 for both the generator regulation and lamp regulation, but work on these controls had been done previous to that date by the J. B. M. Electric Company from whom was purchased the applications, patents, etc.

Consolidated Railway Electric Lighting & Equipment Co.

The most important change in suspension rigging was introduced by the Consolidated Company in the years 1901 and 1902, when the generator was suspended outside of the end of the truck, which is now known as the "outside suspension." The present type "D" Generator was designed about 1904; the Kennedy Regulator at about the same time. The Type "L" Regulator, which is this Company's present standard, was designed in 1911. The Pole Changer used on the present equipment has undergone slight mechanical improvements from time to time. Its general design, however, is as first adopted about fifteen years ago. Ball bearings were first put into service on Consolidated Generators in 1902; on Regulators at about the same time. The Standard bearing, as used on Consolidated Generators today, is known as the TIMKEN Roller Bearing. This is the bearing that has given such universal satisfaction in automobile work and is to be found today in higher class machines. It is supplied with all Consolidated equipments whenever other bearings are not specified. They furnish Generators equipped with S. K. F. Standard or any other of the well known makes of ball bearing that the purchaser may specify. They guarantee the Timken bearing for five years. When a railroad company specifies another make ball bearing they must deal direct with the ball bearing people and procure such guarantees from them as they are able to obtain. The improvements that have been added to Consolidated equipments since July 1st, 1913, are few outside of the perfection of details in the way of design and manufacture. The Generator design has undergone no change whatsoever electrically since it was first put on the market. Mechanically, however, our Generators have been improved by equipping them with Cast Iron Hand Hole Covers with Wing Nuts, improved Brush Holders and the introduction of Timken Roller Bearings and Ball Bearings. The construction of the Type "L" Regulator has been simplified and all the spring adjustments eliminated. Perhaps the greatest improvement that has been added to electric car lighting in a great many years is the Ampere Hour Meter Control of the battery charging current. This has been added to Consolidated Type "L" Regulators during the past few years. This Company has always advocated this method of charging batteries, and at the first Convention (in 1908) of the Railway Electrical Engineers, exhibited a Kennedy Regulator that charged the batteries for a predetermined number of ampere hours. The improvements, however, that have been made in Ampere Hour Meters since that time now enable us to apply the same principles to Type "L" Regulators.

The United States Light and Heating Company.

Development work commenced in 1893. System first placed on the market in 1896. An outside suspension was developed about 1895 or 1896, and an inside suspension in 1898. Pole changers were patented in 1894, and numerous patents covering modifications have been issued from time to time since that date. Generators and regulators were first put in service about November, 1912. Chief Engineer Mr. W. L. Bliss expresses a preference for ball bearings to plain bearings.

The following improvements have been brought out in the year July 1, 1913, to July 1, 1914: (a) Regulating Panels—the chief advances during the year were 1st, the addition of ampere hour meters to panels; 2nd, a decided simplification in mechanism required to secure the duel type of regulation described below; e. g., whereas two carbon piles with their associated electro-magnetic parts were formerly used for regulation, now one simple carbon pile and solenoid suffices for operation of both stages of regulation outlines as follows: The type "C" panels have been modified so as to secure constant current regulation during charging of battery, and when battery becomes fully charged instantly to transform this type of regulation to constant potential regulation at low floating battery voltage so as to enable generator to continue to carry directly whatever load may exist at the time, and also to permit battery to float across line without either receiving or delivering appreciable current.

Notwithstanding the enlarged scope of operation, the new panels are as simple mechanically as the old panels which were standard before the U-S-L Company developed the new form of regulation. An important feature of U-S-L regulation is that this company has now standardized "constant battery current regulation," which means, briefly, that when the generator is charging the battery, if a lamp load is thrown on, the generator will pick up the additional load and will continue to send the same number of amperes of charging current into the battery that it did before the lamp load was thrown on, i. e., regardless of whatever output the generator may be called upon to deliver, the battery regulation will, with operative speed conditions, secure a constant input into the battery.

In conjunction with the foregoing point, the U-S-L Company lays stress on its distinctive method of preventing the battery discharge current to lamps from raising the regulator plunger and thereby increasing the resistance in field circuit and retarding the development of voltage when the machine resumes operation. The point that distinguishes it is that a small amount of current is permitted to flow through the modifying coil of the generator-regulator, and thus to cancel the effect of the current through series coil to lamps. The method of securing plungers to pistons of air dash pots has been improved in that the new universal motion at joints now prevents binding in dash pots.

(b) Lamp regulators, type "B," have been improved so as to secure satisfactory lamp regulation without employing a relay. The type "K" relay is essential for very fine voltage regulation. (c) Generators: Flexible lead with bead insulation have been improved in detail so as to prevent breaking of copper cables near points of attachment to terminals. Adapter designed for converting generators with plain bearings on both ends to combination of plain bearing on commutator end, and ball or roller bearing on pulley end. This enables customers to save old shafts, and thus avoid expense of complete conversion of old machines to ball bearings when the old commutator and brass bearing is still in good condition. Bakelite commutators developed and standardized, and will soon be in production. Both axle and generator pulleys designed to have stationary flanges, thus eliminating a prolific source of belt destruction. A car equipped with this device has shown a belt life of 55,000 miles, the report stating belt still as good as when first applied. New "Foot and Link Bushings," which prevent wear both in generator feet and also in suspension links.

(d) Suspension: New type has been designed such that no amount of wear on any part can affect safe suspension of generator.

(e) General improvements: Substitution of bakelite for fibre and other insulating materials wherever applicable, particularly on thrust plates, contact supports of automatic switches, etc.

Summary—Development Axle Lighting

Consolidated Railway Electric Lighting & Equipment Co.

Changes in Design—
1901-1902—Outside generator suspension.
1904—"D" generator and Kennedy regulator.
1911—Type "L" regulator.
(See 1908 Proceedings.)

Safety Car Heating and Lighting Co.

Development Commenced 1895
First Placed on Market..........................1909
Changes in Design—
1908—Types "A" and "B" equipments were developed.
1910—Type "D" equipment developed.
1912—Type "F" equipment developed.
1913—Present standard suspension developed.
(Some two or three years ago experimented with the German Pintsch-Grob System but not undertaken further, presumably because not considered superior to or possibly even equal to the Type "F" equipment.)

Electric Storage Battery Co.

Development Commenced 1909
First Placed on Market..........................1913
Changes in Design—
Ball bearings supplied with original design.
No radical changes have been made during the year ending July 1st, 1914, although improvements have been made in minor details.

Adams & Westlake Co.

Development Commenced 1901
First Placed on Market..........................1903
Changes in Design—
1903—Regulator perfected.
1904—Suspension rigging, dynamo and pole changer perfected.
1905—Belt casing for dynamo perfected.
1906—Pole changer improved.
1909—Ball bearings applied to dynamo.
1910—Improvements made in regulator.
July 1st, 1913, to July 1st, 1914—Marked change in dynamo design. Several hundred pounds weight eliminated without lowering capacity. Patented redesign of pole changer. (See Railway Electrical Engineer of June, 1914.)

Gould Coupler Co.

Development Commenced 1906
Changes in Design—
1906—Started development of counter machine regulation with electric pole changer.
1907—Ball bearings used on parts of apparatus other than the dynamo.
1908—Took up development of carbon pile regulation for both generator and lamps.
1910—"Simplex" System placed on the market.

Improvements dating from Just 1st, 1913, confined principally to better material and workmanship. A special resistance unit added to generator regulator to increase voltage limit to suit Edison Storage Battery conditions.

United States Lighting & Heating Co.

1894—Pole changers were patented.

1895-1896—An outside suspension developed.

1896—Generator and regulators were built and since developed gradually.

1898—An inside suspension developed.

1912—Ball bearings first put in service.

The last year Ampere hour meters added to panels and a decided simplification in mechanism of regulators.

Bakelite commutator developed. Stationary flanges on both pulleys.

"Foot and Link Bushings" preventing wear in generator feet and suspension links. Suspension improved increasing its safety.

Respectfully submitted:

Roger T. Smith, Great Britain.
E. M. Cutting, U. S. A.
H. R. Bucks, Chairman, U. S. A.

Committee on Data and Information

Your committee has endeavored to continue the work of tabulating car lighting statistics carried on by similar committees during the past three years, and in addition to that work, to endeavor to obtain some data on other electrical equipment in railroad service, from which some interesting and valuable deductions might possibly be drawn.

Tabulated question blanks were prepared in printed form and sent to the ranking motive power officials of sixty-seven of the more important roads, this list including all roads having over 500 miles of main track.

As in past years, this committee has experienced considerable difficulty in obtaining information from certain railroads, although out of a total of sixty-seven roads written to, we received information from fifty. Those roads from which information was received, however, represent a larger figure than this ratio would indicate.

As shown on the last line of Table III, "Car lighting data," there were eighteen roads which reported in 1912 but which furnished no information to this committee. These eighteen roads have a total of 1,344 cars, on the other hand, there are twenty-six roads reported this year which were not reported in 1912. Your committee believes that as railroad officials come to realize the importance of accurate records of their electrical equipment, this report can be made more complete in future years.

Car Lighting Data

Upon referring to Table III, and comparing the car lighting statistics with those of past years, as is done in Table I, it will be noted that the total number of electric lighted cars which were reported has increased from 11,017 in 1911, to 18,936 in 1914, an increase of 71.8% in three years. The increase in straight storage and axle generator cars has been considerably greater than the percentage increase in head-end train lighting sets, this being 97.1% and 111.5% for the straight storage and axle, and only 42.2% head-end cars. This would indicate that although there has been a numerical increase in the number of head-end lighting sets, this increase has only been 38% as great as increase in axle equipments. The data shows that there has actually been a falling off in the use of head-end equipment during the last two years.

TABLE I

INCREASE IN CAR LIGHTING EQUIPMENT IN U. S. AND CANADA

Total Number	1911	1912	1914	Increase in 3 Years
Electric Lighted Cars	11,017	13,115	18,936	71.8%
Cells Lead Battery	202,744	222,989	259,842	28.8%
Cells Nickel Iron	......	4,855	31,883	......
Straight Storage Cars	1,372	2,078	2,707	97.1%
Headend Generator Sets	192	291	273	42.2%
Axle Generator Cars—60 and 30 Volt	5,900	7,198	12,458	111.5%

Another interesting fact brought out by Table I is that, while the number of axle generator cars has shown an increase of 6,558, the storage batteries have been increased by but 57,098 cells of lead battery, and 31,883 cells of nickel iron, these representing a total of 4,850—30 volt cars. The apparent discrepancy in battery equipment is doubtless accounted for by the change in equipments from 60 volt to 30 volt operation, in which case one 60 volt car, then in service, may now be employed on two 30 volt cars.

Water for Batteries.

Another interesting fact shown in Table III is that out of a total of 198 division points reported, 116 of these, or 58%, use distilled water; while 57 of these, or 29%, use tap water, presumably of good quality, such as is found in Chicago. It is rather surprising to note that 11 division points are reported to be using heating plant condensation. This water is very apt to contain flakes of iron rust from the steam pipes or iron in solution, which will seriously injure the battery.

Headlights.

It is interesting to note the increased use of incandescent electric headlights; there are now practically 10% as many incandescent as arc headlights in service. It will be noted from the table, however, that this number is made up almost entirely on two roads.

Car Lighting Costs.

Only a small percentage of the roads giving data on their electrical equipment were able to furnish us any data on cost of electric car lighting and some of the costs which were submitted are very obviously estimated in round numbers. Your committee endeavored to obtain some information as to the methods by which these costs were derived, but have secured only very general statements, which do not convey any definite information. We would recommend that next year's committee refer to the standard blanks for keeping car lighting costs approved by the association in 1912, and endeavor to procure all costs on this basis. The data received is given under Table IV.

As to whether these costs should be kept on a monthly basis or a basis of thousand car miles, the committee will not endeavor to state, but would suggest that this be discussed at the convention.

Shop and Station Equipment

It will be noted that of the total of 45,652 large lighting units reported, these are distributed among the various classes, as shown in the following Table II.

TABLE II

SUMMARY OF LIGHTING UNITS IN RAILROAD SERVICE

	Total Number Reported	
a. c. Arc Lamps	9,600	21. %
d. c. Lamps	8,096	17.7%
Magnetite Arc Lamps	1,429	3.1%
Flaming Arc Lamps	1,252	2.3%
500-watt Tungstens	734	1.6%
400-watt Tungstens	1,576	3.5%
250-watt Tungstens	11,205	24.7%
150-watt Tungstens	9,030	19.8%
Nitrogen Filled Tungstens	489	1.7%
Cooper-Hewitt	1,516	3.3%
Quartz Tube	55	.1%
Nernst Lamps	570	1.2%

Generators.

It was hoped that the committee might be able to deduce an average demand factor from the data supplied on generators and shop motor equipment, this factor being the ratio of the connected load to the rated generator capacity. There was such a wide variation in the factor as computed from the data given, however, that it was decided not to make any comparison of the various roads on this basis. We would recommend that the committee for next year be instructed to frame its questions a little more carefully in this respect than did this committee so that this point may be settled without question.

It is interesting to note that the railroads have practically twice the k.w. generation capacity in a.c. than they do in d.c. generators.

Purchase of Power.

Your committee endeavored to determine to what extent railroads purchase power for their shops. Of the 415 shops reported, 42% of these representing 30% of the total power, purchase power from local central stations, while 58% of the shops, representing 70% of the total power load, generate their own power.

TABLE III
CAR LIGHTING DATA

	Car Lighting												Head End System			Axle Gen. System			Water for Batteries Number Division Points Using				Industrial Trucks					Motor Cars Operated on Rails			Headlights		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
RAILROADS	Total Pass. Cars Operated.	Total Cars Electric Lighted.	Electric Lighted, Owned by R. R. Co	Elect. Lighted, Owned by Pullman Co.	Elect. Lighted Cars on Order.	Cells of Lead Battery.	Cells of Nickel-Iron.	No. Gas Lighted Cars.	No. Oil Lighted Cars.	Combination with Electric.	Straight Storage—60 V.	Straight Storage—30 V.	No. of Turbine Sets.	Recip. Engine Sets.	Head End Cars with Battery.	60 Volt Cars.	30 Volt Cars.	24 Volt Cars.	Distilled Water.	Tap Water.	Heating Plant Condensation.	Filtered Water.	Baggage Handling.	Freight House.	Battery and Commissary.	El. Tractors to Haul Freight Cars.	Shop Trucks.	Straight Gasoline Cars.	Gas. Electric Cars.	Storage Battery Cars.	Elect. Arc Head Lights.	Elect. Inc. Headlights.	Automobiles.
Atlantic Coast Line	679	45	45	.....	15	596	550	295	339	4	0	0	0	0	0	8	37	0	3	...	0	0	0	2	0	0	0	0	0	0	542	0	0
Baltimore & Ohio	1269	213	213	110	...	3952	1500	582	475	.....	59	....	10	0	23	25	80	1	7	7	0	7	0	0	0	0	0	0	0	0	143	0	0
Boston & Maine	2030	213	213	.....	0	32	0	1330	689	11	0	0	0	0	0	0	11	0	...	...	...	..	...	...	..	..	..	...	..	..	0	1 Ex.	..
Can. Pac	2780	352	352	11	0	7085	1482	1904	455	38	.....	....	1	0	0	0	0	352	...	...	..	..	7	20	..	0	0	4	..	..	1388	1	0
Cent. Railway of Georgia	271	32	32	Var's	0	128	650	142	91	6	0	0	0	0	0	0	32	0	All	0	0	0	...	15	..	..	..	0	0	0	336	.....	0
C. & O.	404	231	231	44	0	16	0	17	112	160	0	112	0	0	0	1	162	0	y	n	n	y	0	0	0	0	0	0	0	1	104	0	0
Chic. and Alton	251	60	60	39	0	1120	0	121	30	38	11	4	0	0	0	9	26	0	0	3	0	0	...	...	..	..	..	...	..	..	262	262	..
C. R. I. & P.	1194	414	414	198	0	6976	175	537	243	76	0	0	0	0	0	8	406	0	10	8	0	0	0	0	0	0	10	6	2	0	1300	0	0
C. & N. W.	1735	294	294	51	0	2670	25	1032	651	262	0	0	21	5	34	16	63	0	0	2	0	0	...	...	..	..	*1	...	..	..	......	.....	*2
Chi., B. & Q.	1316	745	745	100	0	3323	0	48	507	598	0	0	‡52	0	100	4	0	0	0	6	0	0	0	10	0	0	0	0	0	0	1196	19	..
Chi. & G. Western	174	81	81	0	0	640	1025	82	11	0	0	0	0	0	0	0	81	0	0	0	6	0	...	...	..	..	1	3	0	0	150	8	..
Chi., Ind. & Sou.	42	10	10	2	...	160	......	30	0	0	0	0	0	0	0	0	10	0	0	0	0	0	...	...	..	..	..	15	..	..	0	0	..
C. M. & St. P.	1630	941	941	0	37	5664	0	16	623	885	56	0	51	11	163	14	2	0	1	2	0	0	...	...	..	..	0	1	7	..	1231	0	0
Chi., St. P., M. & O.	344	35	35	.....	2	272	0	148	129	54	0	0	7	0	...	2	1	0	0	1	0	0	0	0	0	0	0	0	0	0	303	61	0
Clev., Cin., Chi. & St. L.	621	154	154	.....	...	....	......	286	181	3	.....	....	0	0	0	34	120	0	1	1	1	1	0	0	0	0	0	...	..	..	72	7	..
Colorado & Southern	158	9	9	7	0	144	0	68	90	9	0	0	0	0	0	1	8	0	1	0	0	0	...	...	..	..	..	§19	..	..	†160	0	0
Del., & Lack. & West.	925	91	91	67	110	1312	0	554	163	0	0	0	0	0	0	0	91	0	0	0	1	0	3	14	..	..	•2	...	..	..	......	.....	..
Delaware & Hudson	399	1	1	.....	0	64	0	170	224	4	0	0	0	0	0	4	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0
Denver & Rio Grande	381	29	29	40	0	416	0	214	132	0	0	0	0	0	0	1	24	0	2	0	0	0	0	0	0	0	0	0	0	0	385	0	0
Great Northern	1035	655	655	0	80	5392	0	200	180	628	0	0	50	0	140	28	1	0	2	3	0	0	5	0	0	0	0	0	2	0	850	0	0
Ill. Central	1150	260	260	80	1	1792	3950	410	400	.....	6	....	...	..	...	...	260	...	5	1	2	1	1	5	..	..	..	2	4	..	15	.....	..
Intercolonial Ry. of Can.	509	12	12	8	0	240	0	210	299	12	0	0	0	0	0	0	14	6	0	1	0	0	0	0	0	0	0	0	0	0	160	9	0
Kansas City Southern	89	3	3	11	...	96	......	75	10	3	2	1	...	..	...	2	1	...	1	...	..	..	...	...	..	..	..	...	..	..	175	1	0
Lake Shore & M. S.	837	209	209	0	75	4144	50	5	45	9	0	0	0	0	0	42	167	0	3	0	0	0	0	0	0	0	0	1	2	0	3	0	0
Lehigh Valley	483	320	320	45	65	5106	75	73	90	0	.....	....	0	..	...	...	320	...	1	5	1	0	...	50	..	..	..	...	..	..	0	0	50
Mich. Cent.	543	148	148	.....	0	1688	0	210	185	21	0	0	0	0	0	12	136	0	0	All	0	0	10	...	..	..	..	0	0	0	0	8	0
Minn. & St. L.	132	17	17	2	0	136	0	3	112	5	0	0	0	0	0	0	17	0	0	1	..	..	...	...	..	..	..	...	..	..	......	.....	..
Minn., St. P. & S. S. M.	458	116	116	17	10	1968	0	49	276	14	0	0	0	0	0	0	133	0	1	5	0	0	...	...	1	..	..	1	0	0	445	19	0
Mo. Pac	720	77	77	76	39	1216	16A 12H	383	260	35	0	0	0	0	0	0	77	0	...	...	..	..	...	...	..	..	..	...	..	..	......	.....	..
N. Y., Chi. & St. L.	104	10	10	.....	0	192	0	......	.....	6	0	0	0	0	0	2	8	...	0	2	0	0	...	...	..	..	..	...	..	..	......	.....	..
N. Y., N. H. & H.	2267	400	400	.....	15	7008	1245	1571	138	158	0	0	0	0	0	18	382	0	4	0	0	0	...	...	..	..	4	0	0	0	0	0	2
N. Y., Ont. & Western	227	13	13	0	0	0	325	167	47	0	0	0	...	..	...	...	13..	...	2	0	0	0	0	0	0	0	0	0	0	0	6	0	0
Norfolk & Western	442	79	79	30	5	208	2575	175	158	0	0	0	0	0	0	0	79	0	3	0	0	0	0	0	0	0	0	0	0	0	120	0	2
Norfolk & Sou.	92	11	11	4	0	16	250	6	81	0	0	0	0	0	0	0	11	0	3	0	0	0	0	0	0	0	0	1	0	0	77	0	0
Nor. Pac.	......	739	......	.....	...	....	......	......	.....	.....	.....	....	...	..	...	14	....	...	...	...	..	..	...	...	..	..	..	...	..	..	......	.....	..
Oregon Short Line	319	.....	......	.....	...	214	550	191	16	111	.....	0	⊙6	⊙		1	30	...	2	0	1	0	3	...	..	..	..	5	0	0	......	.....	..
Pennsylvania Lines East	2808	1924	1924	628	0	57168	15300	......	.....	0	1634	36	0	0	0	0	882	...	131	6	2	1	150	7	13	1	25	88	0	2	0	33	15
Pennsylvania Lines West	1317	714	714	.....	2	23990	108	5	598	0	637	0	0	0	0	74	3	0	13	0	0	0	0	0	0	0	0	0	0	0	......	.....	2
Pere Marquette	393	114	114	.....	0	1792	0	23	256	68	0	0	0	0	0	0	112	0	0	All	0	0	0	0	0	0	0	0	1	0	26	2	0
Philadelphia & Reading	1136	73	73	55	30	16	0	970	5	0	0	0	0	0	0	0	128	0	1	0	0	0	3	0	0	0	0	0	0	0	0	0	0
Pitts. & L. E.	131	32	32	44	4	560	......	......	.....	1	.....	....	...	..	...	2	30	...	1	...	..	..	3	...	..	..	..	...	1	..	......	.....	..
Pullman Co.	......	5800	......	.....	...	90000	......	......	.....	.....	.....	....	...	..	...		5400		...	...	..	..	...	...	..	..	..	...	..	..	......	.....	..
St. L. So. Western	238	12	12	11	0	368	0	121	55	3	0	All	0	0	0	0	12	0	2	0	0	0	0	0	0	0	0	0	8	0	218	36	0
Sea Board Airline	371	75	75	.....	45	1088	625	150	129	6	0	0	0	0	0	10	65	0	4	0	0	0	0	1	0	0	1	1	0	0	424	0	2
Southern Ry.	1147	258	258	.....	57	....	......	......	.....	.....	0	....	0	0	0	0	258	0	...	...	..	..	...	...	..	..	..	0	2	0	1150	0	0
South. Pac.	1594	244	244	.....	...	5536	775	1107	228	174	.....	7	19	4	6	14	93	0	5	0	0	0	2	0	0	0	0	32	0	0	332	820	..
Texas & Pac.	234	14	14	.....	...	256	25	......	.....	.....	0	0	...	..	...	...	14	...	...	...	1	..	...	...	..	..	..	...	..	..	......	.....	..
Union Pac.	826	494	494	250	42	1968	100	226	82	221	13	....	22	9	44	14	6	0	3	0	0	0	0	0	0	0	1	18	0	0	452	0	0
Wabash	426	66	66	29	...	1668	0	221	1389	1	17	....	0	0	0	0	49	0	3	2	0	0	0	0	0	0	0	0	0	0	248	0	0
Western Pacific	70	64	64	.....	...	1040	......	5	.....	2	.....	....	...	..	...	1	63	...	1	...	..	..	...	...	..	..	..	...	..	..	89	.....	..
Seventeen Roads not included but reported in 1912, as follows	......	2038	......	.....	...	28574	723	......	.....	.....	¶1	12	6	..	...		1806		...	..	..	..	..		..	..	..	..	..	.	......	.....	..
Totals, July 1, 1914	**36896**	**18936**	**10359**	**1918**	**624**	**259842**	**31883**	**14137**	**9941**	**3556**	**2435**	**160**	**244**	**29**	**510**	**367**	**12458**	**359**	**116**	**57**	**15**	**10**	**187**	**124**	**14**	**1**	**45**	**197**	**30**	**3**	**12432**	**1287**	**75**
								Add	545¶																								

---

*Elwell Parker.
‡Have 18 locomotive turbine sets additional.
§Sec foreman's cars.
•Electric locomotives.
⊙Total number of cars headend, 97.
¶Not included in the totals.

TABLE IV
CAR LIGHTING COSTS
MONTHLY BASIS

RAILROAD	All Classes of Cars Pooled St. Storage	All Classes of Cars Pooled Axle Generator	Coaches Straight Storage	Coaches Axle Generator	Diners Straight Storage	Diners Axle Generator	Baggage Straight Storage	Baggage Axle Generator	Mail Cars Straight Storage	Mail Cars Axle Generator	Pulmans Straight Storage	Pulmans Axle Generator	Business Straight Storage	Business Axle Generator	Method of Keeping Costs
*B. & O.	......	......	$17.40	$22.35	$26.00	$40.60	......	......	......	......	$18.85	$30.00	......	$19.80	A
C. & O.	......	......	......	......	......	......	......	......	......	......	30.00		......	......	B
C. & N. W.	......	......	¶ 10.00		20.00		......	......	......	......	30.00		14.00		C
C. R. I. & P.	......	......	13.67		9.53		13.07		13.07		......	......	8.79		C
Del. & Lack.	......	......	9.72		25.21		......	......	......	......	......	......	......	......	C
L. S. & M. S.	9.76	......	......	......	......	......	......	......	......	......	......	......	......	......	B
N. Y. C. & St. L.	......	......	30.00		50.00		......	......	......	......	......	......	10 00		C
N. Y., Ont. & Western	......	......	13.00		......	......	......	......	......	......	......	......	......	......	A
Norfolk & Southern	......	......	21.00		......	......	20.00		......	......	......	......	21.00		C
Penna. Lines	......	......	12.87	25.10	34.31	43.86	......	......	15.54	46.06	28.23	33.21	......	......	C
Sou. Pac.	......	......	5.14		12.90		......	......	18.92		9.16		3.89		A
Union Pacific	......	......	3.00		7.00		2.50		2.00		4.00		3.50		A
Wabash	19.97	24.33	......	......	......	......	......	......	......	......	......	......	......	......	B

Key to Method of Keeping Car Lighting Costs:
A.—Separate account kept for each car.
B.—Expenses for all classes of cars pooled.
C.—Expenses pooled for each class of cars.

*Costs based on method advised by Interstate Commerce Commission. Does not include depreciation, fixed charge or indirect supervision

¶Head end.

TABLE V
SHOP AND STATION EQUIPMENT

RAILROADS	Lamps												Generators				Power				Shop Motors			Transfer, Turn Tables			
																	Purchased		Generated								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26*	
																										Trolley Connection to Table	
	A. C. Arc Lamps.	D. C. Arc Lamps.	Magnetite Arc Lamps.	Flaming Arc Lamps.	500 Watt Tungsten.	400 Watt Tungsten.	250 Watt Tungsten.	150 Watt Tungsten.	Nitrogen Filled Tungstens.	Cooper-Hewitt.	Quartz Tube.	Nernst.	K. W. Capacity, A. C.	Number.	K. W. Capacity, D. C.	†Number.	Number of Shops.	H. P. Connected Load.	Number of Shops.	H. P. Connected Load.	†Total Shop Motor H. P.	No. of Locomotives.	Shop Motor H. P. Per Locomotive.	Elec. Operated Turn Tables.	Elec. Operated Transfer Tables.	Turn Tables.	Transfer Tables.
Atlantic Coast Line	21	....	30	10	....	45	75	‡287	....	....	....	....	1680	5	530	7	1	12	2	2790	1224	720	1.25	1	4	U	U
Baltimore & Ohio	1233	407	148	83	....	137	341	0	27	0	0	0	3160	28	2535	17	6	6043	17	3452	10741	2217	4.86	25	2	O	O
Canadian Pacific (Eastern Line)	....	....	0	....	0	....	0	200	5	10	0	0	2425	6	1158	8	3	1025	2	2360	10195	2052	4.97	....	7	O	O
Central Ry. of Georgia	0	0	81	0	Gen	erall	y Use	d	42	180	0	0	1825	5	628	8	1	3600	1	807	......	......	......	1	1	U	U
Chesapeake & Ohio	80	10	0	0	0	0	250	100	10	124	0	0	1975	6	200	2	1	350	5	3000	2686	766	3.5	1	2	Dep	ends
Chicago & Alton	0	40	0	6	0	0	232	0	0	69	0	0	200	2	1400	12	5	730	5	420	2322	345	†16.73	6	2	U	U
Chicago & Eastern Illinois	46	175	0	12	0	0	0	18	0	0	0	0	300	1	600	2	2	......	3	......	......	......	......	1	1	O	O
Chicago & North-Western	0	121	0	0	0	0	1600	1000	10	68	0	0	3000	11	3950	23	7	1005	13	8241	9178	1786	5.09	12	10	U	U
C., B. & Q.	460	27	0	15	0	0	3	0	2	0	0	0	2060	7	2080	22	3	290	10	6070	5341	1743	3.06	3	6	U	O
Chicago & Great Western	0	0	0	0	0	10	250	375	10	0	0	0	0	0	970	5	3	350	2	1930	3788	289	1.36	4	1	O	O
Chicago, Indiana & Southern	100	....	....	....	....	....	......	35	....	....	....	....	550	4	......	....	1	95	1	900	792	150	5.28	2	1	O	U
Chicago, Milwaukee & St. Paul	....	289	....	....	19	....	......	12	....	20	....	....	300	2	3550	28	1	350	12	9721	......	......	......	24	5	O	O
Chi., St. P., Minn. & O.	63	65	0	0	0	0	64	0	0	26	6	0	775	5	525	7	1	125	4	1390	1538	366	4.20	5	5	U	U
Clev., Cin., Chi. & St. L.	20	0	12	0	0	0	800	500	0	50	0	0	2075	4	1945	9	5	711	13	6102	3686	871	4.23	17	6	O	O
Colorado & Southern	0	0	0	0	0	0	2	0	0	0	0	0	0	0	365	3	1	133	1	772	927	198	5.21	0	1	....	....
Del., Lack. & Western	744	6	54	96	207	....	475	730	....	13	....	....	2775	9	296 ¶1099	8 ¶37	2	5450	2	2493	6242	774	† 8.07	8	4	U	O
Delaware & Hudson	25	0	0	215	0	0	200	0	5	0	0	0	625	3	350	1	9	4200	1	750	3007	467	6.6	10	0	U	U
Denver & Rio Grande	164	4	0	0	0	0	88	13	0	0	0	0	0	0	192	4	7	2113	1	160	1884	616	3.06	1	0	O	O
Grand Trunk Pacific	30	....	....	40	....	....	24	....	....	172	....	....	2350	4	493	4	1	3000	2	130	2177	257	† 8.46	0	0	....	....
Great Northern	465	30	0	75	80	....	64	180	12	0	0	0	9500	15	107	2	5	3000	5	8930	5247	1324	3.96	10	6	U	O
Illinois Central	30	8	0	17	....	600	360	420	150	48	0	0	2300	7	695	3	22	2370	6	4818	7201	1380	5.22	16	4	U	U
Inter Colonial Ry. of Canada	155	0	0	8	0	0	0	0	2	60	0	0	1100	7	580	8	0	0	19	2430	4019	397	†10.1	0	1	U	U
Kansas City & Southern	18	307	0	3	....	....	......	....	1	4	....	....	....	....	800	7	....	......	....	......	159	194	.82	3	1	....	....
Lake Shore & Michigan Southern	0	30	0	15	....	50	250	0	0	39	22	0	1000	3	3425	21	8	2525	3	3190	4934	997	4.95	15	3	U	U
Michigan Central	230	....	....	77	....	....	472	....	....	....	....	....	1075	4	136	4	5	1525	1	14000	3936	713	5.52	7	2	U	O
N. Y., Chi. & St. L.	....	3	....	3	8	....	28	1	....	....	....	....	......	....	75	1	....	......	All	106	117	258	.454	1	1	U	O
N. Y., N. H. & H.	208	484	....	....	88	25	259	....	....	50	....	284	7610	16	700	15	2	68	6	4110	3543	1308	2.71	4	1	U	U
New York, Ontario & Western	0	447	6	0	0	0	0	0	2	0	0	0	0	0	1235	18	0	0	0	0	1519	212	† 7.17	....	....	....	....
Norfolk & Western	690	118	0	18	0	0	0	0	33	12	0	0	3350	12	875 •2250	6 •3	3	4640	5	9036	4475	1055	425	11	0	O	O
Norfolk Southern	0	0	0	0	0	0	0	0	0	0	0	0	......	....	......	....	0	0	0	0	......	......	......	0	0	O	O
Oregon Short Line	32	0	0	28	....	92	533	28	1	0	0	0	170	....	350 §450	....	......	......	....	......	2598	346	† 7.5	4	1	O	O
Pennsylvania Lines East	2955	3667	552	443	193	300	3459	2380	88	250	10	286	62041	61	20158	170	17	2900	52	24520	21347	3767	5.6	19	20	U	U
Pennsylvania Lines West	194	33	204	9	106	63	316	200	21	192	4	0	3810	15	2844	35	5	736	17	10306	10104	2103	4.9	13	6	U	O
Philadelphia & Reading	423	882	202	2	33	....	128	206	40	0	0	0	#1370	#3	#2150	#2	2	50	12	Total	2890	1008	2.68	7	1	U	U
Pittsburg & L. E.	....	....	....	....	....	....	360	60	4	....	9	....	700	3	1235	10	2	400	4	3000	3067	256	†12.0	6	....	U	U
t. L. Southwestern	24	25	....	18	....	....	11	....	....	....	....	....	560	4	250	2	....	......	....	1746	1692	229	† 7.39	....	1	U	U
Seaboard Airline	85	173	14	2	....	12	137	14	18	0	0	0	200	2	875	17	2	78	3	2028	1545	525	2.95	2	2	O	O
Southern Railroad	200	200	....	....	....	....	......	....	....	....	....	....	1090	5	915	12	....	......	....	......	......	......	......	9	3	U	U
Southern Pacific	582	153	126	43	....	139	253	281	....	....	4	....	0	0	772	11	23	8006	4	2398	10489	1384	† 7.56	6	5	U	U
Texas & Pacific	....	34	....	....	....	....	20	....	....	....	....	....	......	....	347	3	....	......	2	522	502	398	1.26	1	....	U	U
Union Pacific	138	61	0	14	....	103	78	266	6	2	0	0	1000	2	993	9	10	1208	4	3436	4672	837	5.58	12	3	O	O
Wabash	85	0	0	....	....	....	55	1600	0	127	0	0	450	3	0	0	4	3250	1	750	3616	722	5.00	4	2	O	O
Western Pacific	....	....	....	....	....	....	18	124	....	....	....	....	......	....	......	....	4	1509	....	......	1198	115	†10.4	....	1	O	O
Totals July 1, 1914.	**9600**	**8096**	**1429**	**1252**	**734**	**1576**	**11205**	**9030**	**489**	**1516**	**55**	**570**	**123401**	**264**	**65077**	**566**	**174**	**61847**	**241**	**146824**	**176954**	**32945**	**5.37**	**307**	**124**		

*Trolley connection to table: O. = Overhead; U. = Underneath

‡100 St. Series lamps.

¶Motor generator sets.

•Rotary converters.

§Syn. motor gen. sets.

#Locomotive shops only.

Shop Motors.

The committee feels that some valuable information has been obtained on the subject of railroad shop motors, although many of the roads apparently do not have complete records of their shop motor equipment. This data is shown in detail on Tables VI, VII, VIII and IX, and shown graphically in the diagram Fig. 1.

TABLE VI

NUMBER OF D. C. MOTORS

Sizes of Motors

Name of R. R.	¼	½	¾	1	2	3	5	7½	10	15	20	25	35	50	Over 50	Total H. P.	Total No.
Atlantic Coast Line	1		1		13	11	23	16	15	13	7	3	2	5	1	1,224	111
B. & O.	17	6	6	11	17	15	28	10	31	26	45	7	32	14	19	5,575	284
Canadian Pacific		1		1	16	16	13	10	16	17	9	25	14	8		2,432	146
C. & O.		1		3		4	5	3	5	8	4	6	4		2	778	45
Chicago & Alton	3		1	1		10	24	12	22	23	6	13	2	8	1	1,811	126
C. & N. W.	15	4	1	18	26	47	54	53	31	36	22	50	28	15	11	6,113	413
C. B. & Q.		3	2	3	9	15	52	25	35	30	12	13	16	8	2	3,007	225
Chicago & Gt. West.	1	1		1	4	2	10	14	21	12	6	21	10	8	10	2,831	121
C. St. P., M. & O.				1	2	6	16	8	6	12		5	6	2	1	925	65
C. C. C. & St. Louis.				1	2	7	13	12	5	6	5	6	3	4	4	1,223	71
Colorado & Southern.		2		1		1	5	7	10	7	5	5	6	1		755	50
Del., Lackw. & W.	4			6	6	21	43	23	7	12		3	7	1	1	1,175	134
Delaware & Hudson		1		3	11	1	4	7	16	6	6	6	4	2	2	1,033	69
Grand Trunk Pac.					5	10	12	4	8	4		3	2	2		515	50
I. C. R. R.		1		2	3	3	3	5	7	10	20	6	4	20		1,978	84
Intercolonial Ry. of Can.				1	2	3	16	10	12	6	11	6	1	3		934	71
Kansas City & Sou.	2			5	1	5	13	14	15	7	14	7		8	4	1,590	96
L. S. & M. S.	1	6	1	1	5	14	29	43	48	51	23	8	7	3	1	2,907	241
N. Y. C., St. L. R. R.	1			2		1		1		1		1				52	7
N. Y., Ont. & West.					7	7	17	8	28	21	9	7	2	3	3	1,519	112
Norfolk & Western	3	1	5	3	3	10	44	43	32	16	32	6	12	14	60	8,301	284
Oregon Short Line								To	tal	H.	P.	1,	291				
Pennsylvania East.	75	25	9	67	71	137										660	384
Penn. Lines West.	1		1	6	13	17	44	42	59	32	37	33	20	10	16	5,842	331
Philadelphia & Read.	4	7	4	5	6	28	24	38	19	8	5	2	3	3	1	1,303	154
Pitts. & Lake Erie	3	1	1	8	9	13	30	32	22	33	13	9	10	2	4	2,479	190
St. Louis Sou.-West.		1		6	11	15	3	9	7	3	3	4	5			597	67
Sea Board Air Line					2	4	7		11	16	1	11	1	3	2	1,055	58
Southern Ry.						25	16	13	18	18	27	6	7	9	10	2,963	149
Southern Pacific			2	2	6	11	25	27	23	15	7	11		7	11	2,559	147
Texas & Pacific	1			3	3	2	4	1	2			2	1		4	497	23
Union Pacific	6	3	2	9	16	32	31	40	24	30	20	4	2	4	3	2,310	226
Totals	138	64	38	179	281	492	606	530	555	479	349	291	218	156	173	70,234	4537

Average size of Motor 15.5 H. P.

TABE VII

NUMBER OF A. C. SINGLE PHASE MOTORS

Size of Motors

Name of R. R.	¼	½	¾	1	2	3	4	5	7½	10	15	20	25	35	50	Over 50	Total H. P.	Total No.
Atlantic Coast Lines	2																	
B. & O.	2	1															1	3
C. & O.		1		2		2											8	5
C. B. & Q.					1		1										6	2
C. & E. I.										1							10	1
Chi. & Ind. & Sou.	5			1													2	6
C. & N. W.											1						15	1
Delaware & Hudson	3	1															1	4
Denver & Rio Grande													2				50	2
I. C. R. R.					2	2		1	1								23	6
N. Y., N. H. & H.	1	1															1	2
Norfolk & Western	1	1	3	1	2	6											26	14
Penn. Railway	69	5		5	7	3		2	2								72	93
Pittsburg & Lake Erie								1	1		1			1			63	4
Southern Pacific	5	9		6	1		1	1	1			1				2	226	27
Texas & Pacific								1									5	1
Wabash					4				1								16	5
Western Pacific		1																1
Totals	88	20	3	5	17	13	2	6	6	1	2	1	2	1		2	525	177

Average size of Motor 3.0 H. P.

TABLE VIII

NUMBER OF TWO-PHASE—A. C. MOTORS

Size of Motors

Name of R. R.	¼	½	¾	1	2	3	5	7½	10	15	20	25	35	50	50	Total H. P.	Total No.
Atlantic Coast Line					8	2	7	10	14	14	5	1	13	5		1,216	78
B. & O.												1				25	1
Chicago & Alton							1			2	1					40	4
C. B. & Q.			3	2	1	9	21	24	35	20	9	8	18	5	2	2,328	157
Chi. and Ind. & Sou.						5		6	7	5	6	1	4	6		790	40
C. St. P., Minn. & Omaha							8	6	2	5		1	1			240	23
Pennsylvania	2	6		12	34	19	93	51	151	103	75	42	34	33	24	10,630	678
Philadelphia & Reading		2		2	4	6	18	19	22	13	13		4	3	2	1,587	118
Seaboard Airline										1						15	1
Southern Pac.		1	2				2	3	2	2	2		3		1	279	18
Totals	2	9	5	16	45	41	150	119	233	165	111	81	65	47	29	17,150	1118

Average size of Motor 15.3 H. P.

It will be noted from referring to the diagram Fig. 1, that direct current motors, while more numerous in the smaller sizes, fall very much below the three phase motors in the larger sizes, reaching their maximum in the 5 horsepower motor. Direct current motors constitute 40% of the total number, and 38% of the total horsepower of motors in railroad shop service.

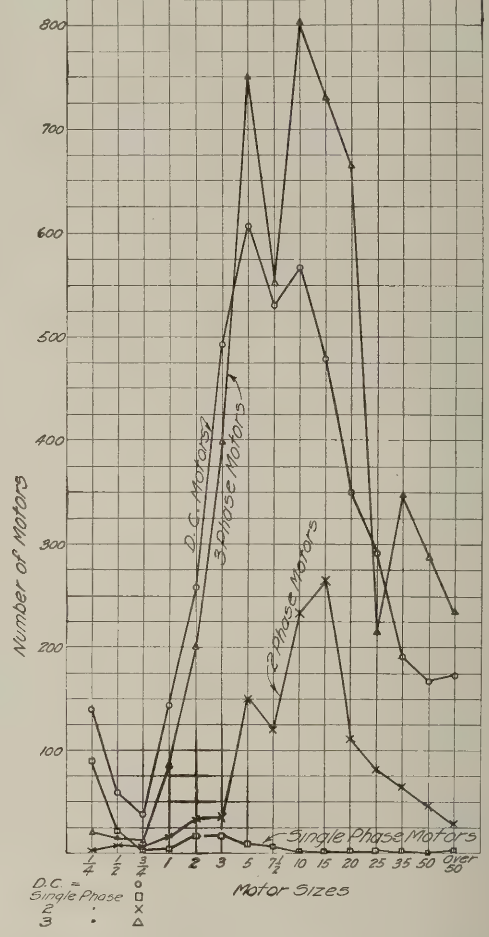


Fig. 1. Total H. P. Motors All Railroads Reported

TABLE IX

NUMBER OF THREE-PHASE MOTORS

Size of Motors

Name of R. R.	¼	½	¾	1	2	3	5	7½	10	15	20	25	35	50	50	Total H. P.	Total No.
B. & O.					3	4	6	5	19	18	73	3	20	26	12	5,140	189
Canadian Pacific				6	5	31	75	28	102	61	80	3	46	23	8	7,763	468
C. & O.							9	2	14	23	6	9	11	9	2	1,900	85
Chicago & Alton						2	4	1	4	5	2	1			3	477	22
C. & N. W.		4	3	5	13	22	38	8	26	11	19	17	22	7	4	3,050	199
Chi. & Gt. West.							4		7	17	8		4	1	3	957	44
C. & Ind. & Sou.																	
Chi., St. P., M. & O.					1	3	4		4	3	3	1	1	1	1	373	22
C. C. C. & St. L.					5	16	20	40	15	20	10	14	8	4	6	2,463	158
Colorado & Southern.								1						2	2	172	3
Delaware, Lac. & West.	3	1	1	11	2	25	74	48	46	42	31	4	26	6	14	5,067	334
Delaware & Hudson						2	10	3	14	26	9	8	11	12		1,973	95
Denver & Rio Grande.	1			1	2	7	5	1	16	13	2	6	2	11	7	1,834	73
Grand Trunk Pacific						11	10	2	11	2	12	14	6	2	6	1,662	76
Great Northern	3		5	1	9	20	24	42	60	57	60	17	16	12	7	5,247	321
I. C. R. R.	7			12	2	39	63	44	57	59	44	6	1	29	22	5,200	369
Intercolonial Ry. of Can.					15	44	51	33	60	34	26		19	1	1	3,085	284
L. S. & M. S. Ry.					1	1	22	19	25	28	11	9	2	3	5	2,027	126
Michigan Cent.				17	11	12	29	27	18	41	25	10	23	20	3	3,936	236
N. Y. Chi. & St. L.										1				1	1	65	2
N. Y., N. H. & H.				8	21	26	32	24	30	20	9	18	12	11	10	3,542	221
Norfolk & Western							8	16	21	15	23	4	3	30	26	3,698	146
Oregon Short Line																1,307	
Penn. Railway East	5			5	43	31	60	47	75	50	50	10	51	17	43	9,985	487
Penn. Lines West.	1	3		3	5	3	29	19	31	36	17	14	12	10	17	4,262	200
Pittsburg & Lake Erie.				3		4	12		8	8	6	2			2	545	44
St. L. & Southwestern.		1			15	4		1	9	8	10		11	2	2	1,095	63
Seaboard Air Line				1		7	8		14	2	6		1		1	475	40
Southern						7	12	15	17	24	21	1	10	15	3	2,322	125
Southern Pac.		4	1	10	21	33	63	43	50	48	32	16	20	21	30	7,425	392
Union Pacific		3		1	7	11	32	27	13	19	19	3	20	4	2	2,362	161
Wabash					13	8	28	36	33	33	48	15	3	7	6	3,600	230
Western Pacific		3		1	7	13	29	19	4	14	3	4	2	4	2	1,198	105
Totals	20	19	12	85	201	386	752	551	803	728	665	215	349	277	242	96,595	5,601

Average size of Motor 17.3 H. P.

It will be noted from referring to the diagram that the single phase motors are used but very little, and except in a few isolated cases are all in the small sizes of motors, the average size being 3.0 h.p. Single phase motors constitute 1.5% of the total number and .3% of the total horsepower of motors in shop service.

It will probably be a surprise to many engineers to learn that there are such a large number of two phase motors in railroad service. These are for the most part used in the larger sizes, as shown in the diagram Fig. 1, coming to a maximum in the 10 h.p. motor and with an average size of 15.3 h.p. for all motors of this type. Two phase motors constitute 9.9% of the total number and 9.3% of the total horsepower of motors in railroad shop service.

Three phase motors are well in the lead of all types, except in the small sizes, under 5 h.p. coming to a maximum in the 10 h.p. size and having an average size of 17.3 h.p. for all three phase motors in use. Three phase motors constitute 49.4% of the total number and 52.3% of the total horsepower of motors in railroad shop service.

Shop Motor Horsepower Per Locomotive.

Your committee desired to deduce from the results in hand a factor which might show the relative number of shop motor horsepower per unit of equipment on the various railroads. From a study of the Interstate Commerce Commission reports it was found that the cost of shop repairs on the three types of rolling stock per unit per year was as follows:

Freight cars	$ 65.60
Passenger cars	727.80
Locomotives	2,332.00

this being on a ratio of approximately 1, 12, and 36. The committee first considered weighting the rolling stock of each road on this basis, but it was decided that since a very large percentage of all shop motors are employed in locomotive repairs only, that simply the number of locomotives should be taken as a basis for computing this shop motor factor.

Col. 22, Table V gives the number of locomotives on each road reported and Col. 23 gives the shop motor horsepower per locomotive. It will be noted that there is a considerable variation from the average of 5.37, but it is very evident from a perusal of the data furnished by those railroads showing a high factor and as indicated by the (†) sign, that many motors other than shop motors were listed, making the total item for shop motors abnormally high. On the other hand, it is very evident that some roads failed to list all of their motors, as is indicated by abnormally low factors in Col. 23.

We would recommend that the committee next year, in requesting motor data, divide motors under the various heads of locomotive repair shop, coal and ore dock, grain elevator, coal shed and water tank, station, draw bridge, miscellaneous, etc. Eliminating the data that is shown to be abnormally high and that which is abnormally low, we find an average of 4.95 h.p. in repair shop motors per locomotive. This is not simply an average of the values given in Col. 23, but is a weighted average obtained by adding totals of horsepower and totals of locomotives and obtaining factor of 4.95 h.p. direct from these totals.

Motors for Travelling Cranes

One of the most interesting facts brought out by the work of your committee is that there exists a very chaotic condition in the matter of motor sizes for shop traveling cranes.

As shown by the accompanying Table X, it will be noted that cranes are grouped by sizes without reference to railroad companies and the average size of motor for each crane size is given in bold face type. It will be noted that there is an extremely wide variation in motor sizes, take for instance, the 5 ton crane: Here we find a variation in main hoist motors from 2 h.p. in the first, to 30 h.p. in the last. A similar variation and lack of uniformity seems to exist in both traction and side movement motors, and further, there seems to be no definite relation between the sizes of side movement, traction, and main hoist motors. A similar variation seems to exist among all the crane sizes.

It will be impossible, however, to standardize on one size of motor for each of the three movements for each size of crane, because of the fact that the speed requirements for handling material vary in different shops and under different conditions. For instance, a traveling crane in a busy shop must hoist its full load and get under way very quickly in order that shop operations may not be delayed, requiring powerful motors; while on the other hand, with a traveling crane in a material yard or other location, where it is called upon to operate only occasionally, and in some cases may go for days without perform-

TABLE X
SHOP TRAVELING CRANES

No. of Cranes.	Capacity in Tons.	Auxiliary Hoist.	Horse Power of Motors		
			Main Hoist.	Traction.	Side.
1	1	..	1	..	...
1	1	..	1	1	H'd
36	1	..	1	..	1
6	1	..	1½	..	...
1	1	..	4	4	2¼
1	1	..	5.4	..	2¼
4	1	..	6	3	2
50	**Av.**	..	**1.14**	**.16**	**.805**
1	1¾	..	13	13	...
1	**Av.**	..	**13**	**13**	...
3	2	..	2¼	..	...
1	2	..	3	3	H'd
1	2	..	3	0	H'd
4	2	..	4½	4½	...
3	2	..	5	5	...
2	2	..	5	5	3
3	2	..	10	10	3
4	2	..	10	10	5
6	2	..	25	11	2
1	2	..	12	6	...
28	**Av.**	..	**10¼**	**6.71**	**4.9**
1	3	..	10	4	2.3
1	3	..	6	..	...
1	3	..	Air	H'd	3
2	3	10	10	10	6
4	3	..	11	15	3
9	**Av.**	..	**8.9**	**9.4**	**3.2**
2	4	..	15	15	5
1	4	..	3	2	2
3	...	**Av.**	**11**	**10.9**	**4**
1	5	..	2	1	...
2	5	..	4	2	2
10	5	..	5	..	...
2	5	..	5	..	...
1	5	..	5	7½	10
1	5	..	6	4	2
2	5	..	7½	..	...
1	5	..	7½	3	H'd
1	5	..	7½	7½	H'd
3	5	..	7½	10	0
1	5	..	10	2	10
3	5	..	10	5	1½
1	5	..	10	3	1½
1	5	..	10	5	2½
3	5	..	10	5	3
2	5	..	10	7	2
3	5	..	10	10	2
2	5	..	10	10	3
1	5	..	11	7½	...
1	5	..	11	8	H'd
3	5	..	11	11	3
2	5	..	12	5	2
3	5	..	12	12	2
1	5	..	15	11	2
1	5	..	15	10	...
1	5	..	15	15	2
1	5	..	16	11	5
3	5	..	21	6½	2½
1	5	..	25	25	2
1	5	..	12	8	2
1	5	..	25	25	3¼
1	5	..	25	12	5
2	5	..	25	18	5
1	5	..	26	24	3
5	5	..	30	15	7½
69	**Av.**	..	**12.05**	**7.16**	**2.2**
1	6	..	7½	4	...
2	6	..	7½	7½	3
1	6	..	12	4	0
5	6	..	11	6	1
1	6	..	20	10	7
10	**Av.**	..	**10.95**	**6.3**	**1.8**
1	7½	..	7½	7½	7½
1	7½	..	7½	7½	3
2	7½	..	11	7½	2
1	7½	..	11	11	3
1	7½	..	4	..	...
1	7½	..	8	8	4
2	7½	..	10	10	4
1	7½	..	10	10	3
2	7½	..	15	5	2
1	7½	..	18	7½	4½
1	7½	..	20	10	3
1	7½	..	25	25	3¼
15	**Av.**	..	**11.5**	**8¾**	**3.05**
1	10	.	7	7	...
3	10	..	...	..	...
1	10	..	11	11	3¼
1	10	..	11	10	7½
1	10	..	10	3	3
3	10	10	10	5	10
9	10	..	15	15	5
1	10	..	15	15	3
4	10	..	20	7½	...
1	10	..	20	12	2
1	10	..	18	12	3
1	10	..	20	5	11
1	10	..	20	25	3
1	10	..	20	25	3
1	10	..	20	45	...
1	10	..	22	10	5
1	10	..	22	11	3
3	10	..	24	12	4
8	10	..	22	10	2½
12	10	..	22	22	10½
1	10	..	20	40	5
7	10	..	25	3	12
1	10	..	25	30	3¼
2	10	..	25	10	3
2	10	..	25	12	3½
5	10	..	25	15	3¼
2	10	..	25	18	5
15	10	..	25	2¼	3
1	10	..	25	25	15
1	10	..	25	25	10
1	10	..	35	10	2½
2	10	..	35	35	5
1	10	..	40	32	12
1	10	..	50	22	5
2	10	..	50	20	6
3	10	..	50	25	3
6	10	..	132	45	66
108	**Av.**	..	**26.5**	**15**	**8.55**
1	12	..	10	3	0
1	12	..	25	18	3
3	12	..	20	20	5
12	12	..	25	18	5
5	12	..	25	25	3
22	**Av.**	..	**23.6**	**19.2**	**4.2**
1	15	..	3½	..	...
1	15	..	10	7½	2
1	15	..	18	12	5
1	15	..	20	20	5
1	15	..	20	..	...
1	15	..	20	15	10
1	15	..	22	22	3
1	15	..	22	22	7½
1	15	..	20	20	2½
1	15	..	24	24	4
3	15	..	21	12.5	3.6
2	15	..	22	..	...
1	15	..	25	8	5
3	15	..	25	25	5
1	15	..	25	25	3
1	15	..	30	15	5
1	15	..	30	20	5
4	15	..	32	18	5
2	15	..	50	50	10
28	**Av.**	..	**25.9**	**17.7**	**4.4**
1	20	2	7½	7½	...
2	20	..	7½	5	10
1	20	..	15	10	3
2	20	..	20	15	7½
1	20	..	20	20	5
1	20	..	22	22	6
2	20	..	36	25	6
1	20	..	25	25	3¼
2	20	..	30	16	7½
1	20	..	45	30	5
1	20	..	40	25	2
1	20	..	28	18	4½
2	20	..	50	25	3
1	20	..	36	36	8
19	**Av.**	..	**31.7**	**20.8**	**5.53**
1	25	..	15	5	...
1	25	..	20	4	5
1	25	..	20	6	...
1	25	..	20	20	5
2	25	..	20	40	5
1	25	..	25	8	8
2	25	..	30	30	5
1	25	10	30	10	7½
1	25	..	30	25	6
1	25	..	32	8	8
1	25	..	40	30	10
2	25	..	40	40	8
2	25	..	40	20	5
2	25	..	50	40	8
3	25	..	75	30	5
22	**Av.**	..	**30.3**	**24.8**	**5.75**
3	30	..	10	5	10
1	30	7½	10	7½	7½
1	30	15	30	10	5
1	30	15	30	15	3
1	30	25	50	25	10
1	30	..	25	12	8
1	30	..	25	20	10
2	30	..	25	10	2
1	30	..	30	10	5
1	30	..	28	22	6
2	30	..	66	33	3¼
2	30	..	30	30	5
1	30	..	47	15	7
1	30	..	32	18	5
2	30	..	30	50	10
3	30	..	32	12	8
1	30	..	32	12	8
1	30	..	37	22	5
1	30	..	45	45	7½
1	30	..	50	22	10
1	30	..	50	25	7
4	30	..	55	25	6
1	30	..	62	8	32
1	30	..	70	30	6
1	30	..	84	30	13
38	**Av.**	..	**37.1**	**25.1**	**7.48**
1	40	45	24	16	19
8	40	..	53	32.4	8
1	40	..	10	10	5
1	40	10	23	20	10
1	40	..	30	30	7½
1	40	..	40	50	11
2	40	..	66	33	3¼
1	40	..	60	35	20
4	40	..	236	60	148
20	**Av.**	..	**83.9**	**36.3**	**36.7**
1	50	35	50	30	25
4	50	..	28	28	7½
1	50	..	50	25	15
1	50	..	50	50	7½
1	50	..	65	50	10
4	50	..	68	39	7
2	50	..	80	30	10
1	50	20	40	50	10
2	50	Rop	e driv	e ru	n by
		15	H. P.	mot	ors.
1	50	..	56	10	56
18	**Av.**	**3.06**	**47.5**	**24.6**	**11.2**
1	65	..	40	25	5½
2	65	..	50	30	7½
3	65	..	71	50	18
2	65	..	70	15	50
1	65	..	80	65	80
1	65	..	35	20	10
4	65	..	380	44	208
2	65	36	55	55	10
2	65	17	59	59	9½
2	65	20	65	45	15
2	65	20	65	65	15
22	**Av.**	**8 5**	**121**	**43.3**	**54**
2	75	..	75	50	7½
1	75	..	80	50	15
1	75	..	160	50	20
1	75	36	65	65	18
2	75	..	80	90	15
2	75	..	72	50	11
2	75	..	125	50	25
2	75	..	120	65	10
13	**Av.**	..	**80.0**	**59.5**	**14.6**
1	80	..	30	5	15
1	**Av.**	..	**30**	**5**	**15**
1	90	..	20	10	5
1	**Av.**	..	**20**	**10**	**5**
1	100	..	100	50	15
1	100	..	55	35	10
1	100	..	60	40	20
2	100	..	75	25	7½
1	100	..	185	100	15
1	100	..	185	50	20
1	100	..	96	36	24
1	100	..	110	55	7½
1	100	..	128	55	15
1	100	..	110	50	20
1	100	..	40	..	...
2	100	..	155	24	65
1	100	..	52	..	...
15	**Av.**	..	**95.2**	**36.4**	**19.5**
1	120	..	120	50	11
1	120	..	130	65	36
1	120	..	88	44	20
1	120	..	70	50	10
1	120	..	126	75	30
1	120	..	130	20	60
2	120	..	170	65	36
1	120	..	22	..	...
1	120	..	52	52	15
2	120	..	90	45	30
12	**Av.**	..	**105**	**48**	**26**
1	125	50	100	50	2
1	125	..	...	..	...
1	**Av.**	**50**	**100**	**50**	**20**
1	130	18	65	65	65
1	**Av.**	**18**	**65**	**65**	**65**
1	150	..	140	..	...
1	150	..	195	36	85
1	150	..	100	50	15
3	**Av.**	..	**145**	**28.6**	**33.4**
1	200	..	164	82	44
Totals. 427		483	18220	10361	5091

TABLE XI

GANTRY CRANES

No. of Cranes	Cap. Tons	Horse Power of Motors			
		Aux. Hoist	Main Hoist	Traction	Side
1	2	..	6	4.5	4.5
1	**Av.**	..	**6**	**4.5**	**4.5**
1	3	..	6	...	...
2	3	..	44	22	8
3	**Av.**	..	**31.3**	**7.3**	**2**
3	5	..	22	22	8
1	5	..	12	4	2
2	5	..	12.5	9.5	...
1	5	..	50	...	...
7	**Av.**	..	**21.8**	**11.8**	**3.6**
1	8	..	7.5	...	...
1	8	..	15	5	5
2	**Av.**	..	**11.2**	**2.5**	**2.5**
1	8	..	11	11	6
1	10	..	11	...	3.25
1	10	..	15	15	75
1	10	..	18	18	5
1	10	..	22	22	5
1	10	..	25	...	...
4	10	..	25	25	10
1	10	..	45	...	...
2	10	..	110	50	25
1	10	..	135	50	25
13	**Av.**	..	**37**	**24.2**	**15.6**
1	15	..	5	7	7.5
1	15	..	15	...	...
1	15	..	33	33	3.25
1	15	..	40	32	5
..	..	..	93	72	16
4	**Av.**	..	**23**	**13**	**4**
2	20	22	22	22	11
1	20	..	50	35	3.5
1	20	..	52	22	6
4	..	..	..	...	...
8	**Av.**	**5.5**	**38.3**	**25**	**8**
3	25	25	25	25	5
1	25	..	30	5	...
1	25	..	32	10	...
1	25	37	37	25	5
2	25	..	50	33	5
1	25	..	50	50	7
1	25	..	50	50	11
10	**Av.**	**11.2**	**37.4**	**28.1**	**4.8**
2	30	22	22	22	7.5
2	30	..	30	30	11
1	30	..	55	25	5
1	30	..	55	30	10
1	30	..	60	37	7.5
1	30	..	60	50	5
1	30	..	64	18	18
1	30	..	65	40	15
10	**Av.**	**2.2**	**46.3**	**30.4**	**9.8**
2	35	..	99	67	18
2	**Av.**	..	**99**	**67**	**18**
1	40	..	50	15	5
1	40	37	52	37	8
1	40	..	55	40	7.5
1	40	..	74	37	10
2	40	..	126	74	3
6	**Av.**	**6.1**	**97**	**46.1**	**15**
1	60	..	50	...	7
1	**Av.**	..	**50**	...	**7**
4	110	..	75	...	...
4	**Av.**	..	**75**	...	...
1	150	..	60	10	...
1	160	..	50	...	...
70	..	193	2673	1515	458

ing any service, it would not be good economy to install powerful motors such as would be warranted in a busy shop.

This fact undoubtedly explains to a large measure the great variation in motor sizes for a given crane size. Furthermore, the lack of standardization in the manufacturers' motor frame sizes enters into the proposition to a certain degree and causes some variation.

It would undoubtedly be possible, however, to standardize on probably three speeds at which to operate traveling cranes, and motor sizes could then be standardized for each of these speeds. Your committee recommends that a special committee be appointed to consider this subject and to report next year, recommending standard sizes of motors for traveling cranes, and, if possible, standard mountings for these motors.

Gantry Cranes.

It will be noted that there is a similar variation in motor sizes for gantry cranes, as shown in Table XI, and the same explanations of this variation and the arguments for standardizing on operating speeds and motor sizes apply here. Your committee would recommend that this subject be also taken up by the committee which makes a study of shop traveling cranes.

It will be noted that the last two cranes of Table XI have a capacity of 150 and 160 tons respectively. Since a gantry crane merely performs the functions of unloading cars, it would seem that these cranes are considerably larger than would ever be required, as the maximum capacity of a car at the present time is about 140,000 pounds, or 70 tons. The 100 ton cranes, which usually have an overload capacity of 50% could take care of even a double car load.

Respectfully submitted,
T. V. Buckwalter, Pa. R. R.
C. J. Causland, Ch. Elec. Pa. R. R.
B. F. Bilsland, General Elec. Co.
A. J. Farrelly, Elec. Engr., C. & N. W. Ry.
J. E. Gardner, Elec. Engr., C., B. & Q. Ry.
W. M. Wiggins, Elec. Fore., Pullman Co.
Edward Wray, Chairman, *Ry. Elec. Engr.*

Committee on Electric Headlights

During the last two years more locomotive headlights have been installed than in all the previous years of electric headlights. Most of these equipments were installed in compliance with the laws of various states. As the interpretation of these laws has caused quite a difference of opinion, it was only natural that the installations were not made until near the expiration of the time set by the law. This resulted in the equipment being installed in a somewhat haphazard manner, by inexperienced men, and lack of uniform methods.

Very few of the railroads today have adopted a standard wiring system, and where such systems have been adopted, they have not been lived up to. Inquiry by the committee of many railroads show that all are now trying to standardize wiring and equipment, and while this committee at this time can only suggest the best practice from our point of view, it is to be hoped that a discussion at this meeting will settle some of the points upon which this committee could not entirely agree.

Type of Machine.

For many years a series type of generator has been in use, and was generally conceded to be the only practical machine. In the last two years all manufacturers of headlight equipment have standardized on a compound wound machine. While both types have their advantages and disadvantages, the majority of the equipments sold today are of the compound wound type.

Three voltages are in use, namely, 6 volt for incandescent lamp machines, and 30 volt and 110 volt machines for arc or incandescent. The 6 volt machine has not found favor on account of the constant attention necessary to commutator and the many cases where these low voltage generators will not pick up.

The 30 volt machine is undoubtedly the best voltage for arc lighting, but at the present time, it has not been possible to manufacture an incandescent lamp for this voltage that is durable.

The 110 volt machines have been used by few railroads and for headlight work do not seem practical.

Location of Generator.

Location of the generator on the engine has caused considerable worry to most mechanical departments, and there is a wide difference of opinion at the present time. Where possible, it seems most practical to locate the generator directly in front of the cab.

Voltage Adjustment.

To determine the voltage of the generator seems at present to be one of the hard problems to solve. With the compound wound machine there is usually about 1½ volts drop in the series field coil and practically the same drop in the engine wiring. Determining the voltage by the speed of the turbine has long been the practice, but the advent of high speed machines has caused the speed indicator to give very inaccurate results. Then, too, all machines will not give the same voltage at the same speed. On account of the fragile construction of a voltmeter, their use could not be encouraged for roundhouse employees. Your committee believes that the average headlight man can judge from the candlepower of the lights in the cab without the arc burning whether the generator is giving the correct voltage or not. This method requires much less time and has worked out well on many roads.

Cab Lamps.

This committee would recommend that a standard candle power and voltage for cab lamps be adopted. It has been found that the voltage of compound wound generators of the 30 volt type has a variation in the cab of from 5 to 10 volts, from when the arc load is on to when only the cab lights are burning. This makes it necessary for the cab lamps to be capable of standing about five volts more than the working voltage of the generator with the arc load. At the present time, lamp voltages run from 28 to 40 volts used with 30 volt machines. The result has been that the lamp manufacturers have not carried a standard headlight lamp and the cost to the railroads have been proportionately higher.

Reflectors.

Many of the railroads in equipping their engines with headlights have built over the old headlight cases used for oil, using the shallow reflectors. While this seemed to be a necessary expedient at that time, an effort should be made to purchase 18x 10½ in. reflectors, as the old reflectors are generally worn out. It is hard to get a perfect beam of light with these shallow reflectors.

Wiring.

Few roads agree on a uniform system for wiring engines. Some have blue prints showing their wiring standards and list of materials. Wiring in the hand rail has many disadvantages and usually costs more than a separate conduit. Nevertheless the majority of the railroads today are wiring their engines through the hand rail.

Using a 1 in. conduit with condulets at outlets with a special connection box on the cab, so that the cab or conduit can be removed without interfering with the wires, offers the best solution of this wiring problem. The cost of such a system will be less than one using armored conductors, and where it is necessary to take down the hand rail and drill for wires, will be cheaper than open wiring in the hand rail.

Wiring of cabs can be done either with wooden cleats, using ceiling buttons and reinforced lamp cord for drops, or a conduit system. The disadvantages of a conduit system in the cab is the difficulty of making repairs by the average headlight man in the roundhouses. With the open wiring it requires little experience to make necessary repairs. The expense of this system is about one-third of a conduit installation. A standard fixture for the water glass and steam gauge lamps should be adopted by earch railroad. They should be designed so that the socket will be attached by means of a lamp guard or other means by which the socket can be taken off for repair. The practice of soldering fixtures on sockets should be discouraged.

The committee last year recommended S. B. W. P. copper wire, and while the majority of railroads are using this wire, there are others who feel that the No. 8 wire should be D. B. R. C. stranded copper wire. The cost of this wire will be almost four times the cost of weatherproof insulation, and it is extremely doubtful if it could be made to last four times as long. There are many arguments in favor of stranded copper wire, but its high cost of this wire is the greatest objection.

Where slow burning weatherproof wire is used, the slow burning insulation should be on the outside with the weatherproof on the inside.

Repair Parts.

This committee recommends that a standard list of repair parts be carried in stock at each terminal point, and that the general stock be concentrated at a general storehouse. Such a stock can be carried for about $15. When the number of engines justifies it an extra generator should be carried in stock at terminal points.

Incandescent Headlights.

While all railroads have been experimenting for some time with Mazda tungsten and nitrogen lamps for headlights, there is not on the market at the present time a concentrated filament high candle power lamp that has a sufficiently long life to justify its use. There seems no question but that such a lamp will be produced within the next few months, as all the manufacturers are now working along that line. When these lamps are a commercial article the arc lamp will be a relic of the past on engines, as well as for shop and yard lighting.

Headlight Reports.

It is recommended that a system of weekly headlight reports, showing the number of engine lighting failures, amount of repair parts used and the labor of headlight men. This report should be signed by the headlight man in each roundhouse and O. K.'d by his foreman. This report should be forwarded to the men in charge of headlights over the entire system.

Battery Headlights.

This committee calls attention to the battery headlights which are used with good results on the Southern Pacific R. R. The lamps are 140 candlepower nitrogen filled tungstens and require 13 amperes at 6 volts. The lamps are mounted in standard oil lamp reflectors. They also use three cab lamps and two blizzard lamps on each locomotive.

The batteries have the capacity to run the entire lighting equipment for 13 hours. The batteries have an e. m. f. of 6 volts and a capacity of 300 amp. hrs. and the cells are made up of iron-clad lead plates. They are mounted on top of the boiler and are removed each trip with a jib crane for charging.

CHARLES R. SUGG, chairman, Atlantic Coast Lines Ry.
GEORGE E. MURRAY, C. & N. W. Ry.
J. J. HACK, Southern Pacific Ry.
JOHN E. GARDNER, C., B. & Q. Ry.
L. C. HENSEL, St. Louis & San Francisco Ry.

Committee on Head End Equipment

The object of this report is to cover the development and progress of axle light equipment in head end service during the last year.

Our report is necessarily confined to the description of unit axle light equipments developed and used by the Northern Pacific Railway Company, as we do not know of any other railroad using this system of electric train lighting.

Development of Head End Axle System.

Following is a brief review of the development of the Unit Axle System prior to October, 1913.

In 1909 the Northern Pacific Company experimented with perhaps the first axle machine designed to light an entire train. This machine was belt driven and was mounted on a cast steel sub-base bolted to the top of the car truck in a manner very similar to the mounting of the latest machine of this kind.

In 1912 three trains, running between St. Paul and Winnipeg, were each equipped with a 4 K. W., 50-ampere, 80-volt, "Safety" axle-driven generator outfit. The four cars in each of these trains which are lighted by electricity are an observation car, a dining car, a day coach and a smoker. The equipment on the various cars is as follows:

Lamp regulators wired complete under all cars; 9 plate, 200-ampere hour batteries under observation car and day coach only; axle generator under dining car. The total lamp and fan load is 50.5 amperes. Generator cuts in at a speed of 18 miles per hour.

In 1913 seven trains, running between Seattle and Moclips, Washington, and Centralia and South Bend, Washington, were each equipped with a 4 K. W., 50-ampere, 80-volt, "Gould Simplex" axle-driven generator. The three cars in each of these trains which are lighted by electricity, are a parlor or cafe observation car, a day coach and a smoker. The equipment in the various cars is as follows:

Lamp regulators in all cars; 9 plate, 200 ampere hour batteries under observation car and day coach only, axle generator under observation car. The total lamp and fan load is 37 amperes. Generator cuts in at a speed of 12 miles an hour.

All the 4 K. W. equipments mentioned above are giving complete satisfaction. The train men now understand what is required of them in the way of putting up train connectors, turning off the lights when they are not necessary, etc. The use of six-inch, 4-ply Balata belts has practically eliminated belt slipping.

20 K. W. Head End Axle Generator.

The latest axle machine designed to light an entire train is known as the "Gould Axle Train Lighter." The first of these machines was installed in Northern Pacific Baggage Car No. 295 and placed in operation on the first day of April of this year.

The "Gould Axle Train Lighter" is a 20 K. W., six pole, commutating pole, compound wound, 80 volt, 300 to 2,100 R. P. M., generator mounted on a cast steel base arching the center sills and extending through the car through two rectangular holes in the car floor. See Figures 1 and 2.

The machine is driven by a Morse silent chain from a counter shaft which in turn is chain driven from the forward axle of the forward truck. The wheels on this axle do not have a brake beam.

The machine itself is ring oiled but the counter shaft is equipped with ball bearings.

The chain from axle to counter shaft is encased in an oil tight galvanized iron case and runs in a bath of heavy valve oil and graphite. The generator chain is not encased and is greased at intervals with a mixture of Kent's compound and flake graphite (half and half). Chains are being run this way for the purpose of observing the wear of chains and sprockets, encased and open.

The entire machine is covered with a wooden box fastened to the car floor and fitted with hinged covers. See Figure 1.

The electrical circuits are in general similar to the standard head end system of the C. M. & St. P. Ry. The lamps are across the outside train lines (1 and 3); the batteries and the generator are across train lines 1 and 2. The lamp current at present passes through a temporary variable resistance between train lines 2 and 3, causing a drop from charging voltage to 64 volts. A large lamp regulator of 125 amperes capacity is being constructed to take the place of the hand operated variable resistance and other test equipment now in the car.

The generator controlling apparatus consists of a regular Gould generator panel constructed on a large scale. The current coil limits current to 125 amperes, while the voltage coil limits generator voltage to 80 volts. The current coil is equipped with a shunt resistance that causes it to limit current to 250 amperes if this is desired. The main switch closes at 66 volts, or when train speed reaches 18 miles per hour. Temporarily there is installed a solenoid which short circuits the variable loop or lamp resistance when the main switch drops out. The new lamp regulator, which will be large enough to take care of the entire train, will take care of this feature.

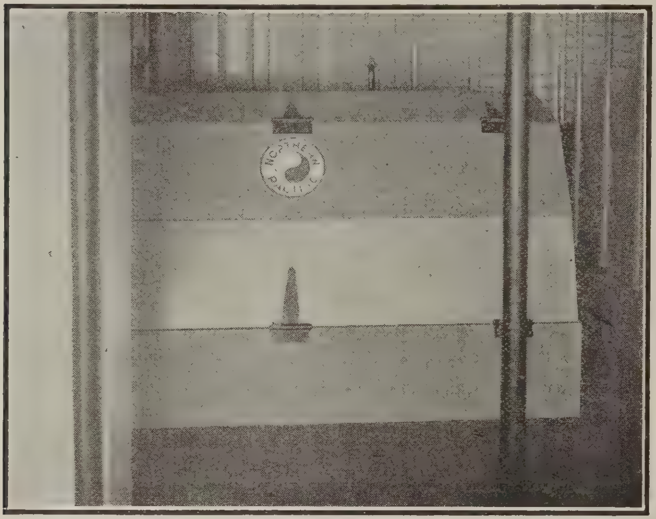


Fig. 1. Machine Covered With a Wooden Box

Operation.

The Gould axle train lighter has been run in the following trains:

Trains 7 and 8, St. Paul to Glendive, Montana, and return, 667 miles each way. Maximum lamp load 83 amperes. Battery capacity 600 ampere hours at eight hour rate. Slow local schedule.

Trains 5 and 6. St. Paul to Seattle and return. 1,904 miles each way. Maximum lamp load 100 amperes. Battery capacity 600 ampere hours at eight-hour rate. The generator was in operation 81.8 per cent of the total running time, and idle 18.2 per cent of the time.

Trains 19 and 20, St. Paul to Winnipeg and return. 481 miles each way. Maximum lamp load, 80 amperes. This load was on from 5:30 to 9:30 P. M. (four hours) going north and from 4:45 to 9:30 (4¾ hours) coming south.

This train leaves St. Paul at 5:50 P. M., arriving in Winnipeg at 9:15 A. M. It leaves Winnipeg at 5:15 P. M. and arrives in St. Paul at 8:30 A. M. The train makes seventeen stops in the 481 miles. This is an average of 28.3 miles between stops. Over one division a schedule speed of 44.8 miles per hour is maintained.

The Gould axle lighter has made the following mileage to date without a light failure:

	No. of trips	Miles
From St. Paul to Glendive, Mont., and return	2	2,668
From St. Paul to Seattle, Wash., and return	1	3,808
From St. Paul to Winnipeg, and return	32	30,796
Total miles		37,272

Due to the fact that the lamp regulator has not arrived, no reliable instrument readings have been taken.

The equipment is practically hand operated at present. The generator voltage is controlled by means of a sliding weight on an extension of the lever arm actuated by the voltage coil on the machine regulator. The lamp voltage is controlled by switching in and out resistance in the lamp circuit. During the important lighting hours (between dusk and about ten o'clock) the difference between lamp and charging voltage is maintained as low as possible without causing a reversal of battery current into the generator. This is accomplished by maintaining a charging current of only about five amperes. The reason for maintaining this low generator voltage is to reduce to a minimum the flicker on the lights when the main switch drops out and the lamp resistance is short circuited.

After ten o'clock the generator voltage is raised to about 75 volts. In the morning when all lights are turned off the generator voltage is raised to 78 volts, at which point it remains during the day. The charging current, of course, tapers off as the batteries become charged.

The 20 K. W. generator at 80 volts will give 250 amperes. This would be the normal charging rate for ten 200 ampere hour storage batteries. As the largest number of these batteries ever operated with this equipment was three, it would seem that there was danger of greatly overcharging them. Observation showed, however, that due to the back E. M. F. of the batteries they seldom took more than twice their normal current, and this for very short periods after a considerable period of discharge. Of course, if the batteries had been in poor condition the charging current would have been prohibitive.

In our opinion a 15 K. W. machine for this service has all the capacity necessary for any train in this country. Such a machine would deliver 200 amperes at 80 volts. With steam generation it is convenient to light and charge at the same time, so perhaps a 25 K. W., 300 ampere, turbo generator is desirable. The axle machine, however, will deliver its full rated capacity twenty-four hours a day if necessary and for this reason a smaller machine will give results. A 15 K. W. machine will not only cost less than a 20 K. W. but will take up less space in the car and due to its lighter weight will be easier on the truck.

Bearings.

It was found that the ring oiled bearings on the generator do not give satisfaction. The rocking and jolting of the machine as it rides on the truck tends to splash the oil on the commutator, causing excessive sparking. The loss of oil due to splashing would also cause a lack of lubrication which would be dangerous on a long trip without an attendant.

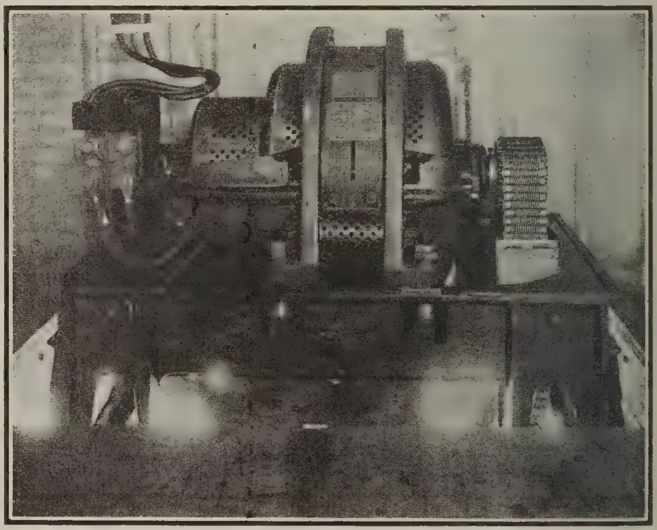


Fig. 2. Generator With Cover Removed, Showing Method of Support and Morse Silent Chain

Except when going through yards and over crossings, etc., the machine rides surprisingly smooth and steady. All who have seen the machine in operation have remarked on this. There is also a noticeable lack of noise when the machine is running.

Chain Drive.

The Morse silent chains are giving excellent results. The teeth wear quite rapidly until they fit the gear teeth. After they have worn to a fit, however, the additional wear is hardly perceptible. We have not been able to notice any wear on either the chain or teeth after the first three thousand miles. After the machine had run twenty thousand miles a careful examination was made of both chains. It was found necessary to take two inches of slack out of the long vertical chain while the shorter horizontal chain from axle to counter shaft showed no extra slack. This is no doubt due to the greater number of joints in the long chain and also to the fact that the short chain is running in a bath of oil.

Lamp Regulation.

During the development of the Unit Axle System it was found that the expense of installing a lamp regulator in every car was a rather formidable argument against the use of the system. To overcome this difficulty it was decided to use one large lamp regulator that would take care of the entire train. This at once brought up the question of what would be the correct current limits for such a regulator. As it is desirable that one size and type of lamp regulator take care of any train from the largest to the smallest, we believe that such a regulator should be designed to take care of changes in lamp load from 30 to 150 amperes. We also believe that the maximum variation in voltage allowed should not be more than three per cent either side of normal. With a 64 volt system this would allow a variation from 62 to 66 volts. At present lamp voltage is controlled by hand adjustment.

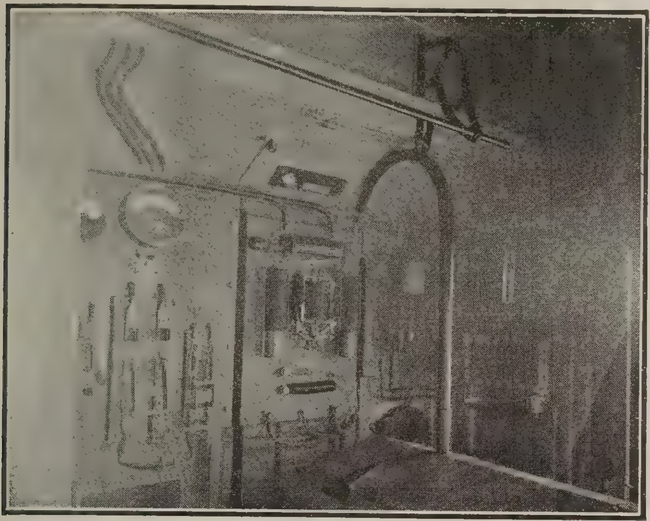


Fig. 3. Regulating Panel and Switchboard. Automatic Lamp Regulator will be Added Later

Cutting-in Speed.

In regard to correct train speed when main switch closes. It has been found on the Northern Pacific that this speed should not be less than twelve miles an hour for slow local runs with many stops and not less than 18 miles an hour for the faster runs with few stops.

We have found that the best results are obtained with the Unit Axle System when the main automatic switch closes at a generator voltage of 66 volts. This is when switch and coil are cold.

Location of Batteries.

The distribution of the batteries on the train equipped with the Unit Axle System is a point to be considered. It is the practice on the Northern Pacific to place 9 plate, 200 ampere hour batteries under the postal car, if any, the dynamo car, the standard sleepers and the observation car. The advantages of this scheme are:

1. Sufficient batter capacity insured. The battery under the postal car will take care of itself whether in the train or in the yard. The battery under the dynamo car will provide the current for itself and the day coaches; the batteries under the standard sleepers and observation car will provide current for the remaining cars in the train including diner and tourists, etc.

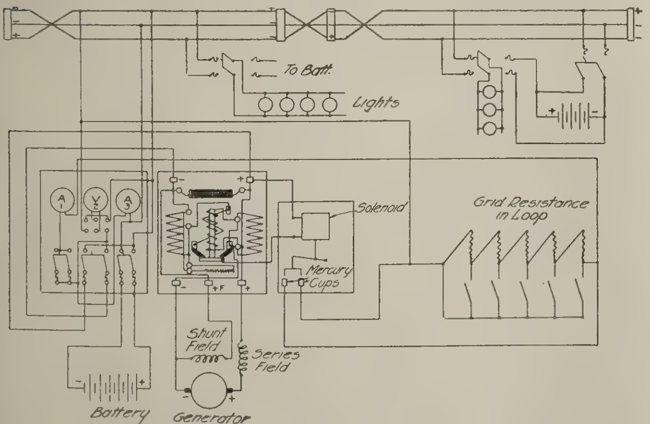


Fig. 4. Wiring Diagram of Generator, Regulator Batteries and Train Line

2. The cars equipped with batteries are most in need of them when detached from the train.

In regard to the most desirable capacity per set of batteries. The Northern Pacific is having very good success with the 9 plate, 200 ampere hour size. However, a discussion will be welcomed on just what the most desirable capacity of each set should be.

One fundamental difference between a steam head end system and a Unit Axle System is that with the latter system the lamp load is carried by the batteries at every stop the train makes. For this reason steam head end experience cannot be used as a basis for determining the exact relation that should exist between the connected lamp load in the train, the current output of the generator and the total battery discharge current at the eight-hour rate.

Operating Results.

Following is a discussion of the various conditions met with on the Northern Pacific Railway:

South Bend Trains. Two trains running between Centralia and South Bend, Washington. Each train makes twenty-five stops in the 57 miles, and in addition runs very slowly over five miles of heavy grade. One train leaves Centralia at 8:00 P. M. and arrives at South Bend at 10:55 P. M. where it lays over until the next day until 4:20 P. M., at which time it leaves for Centralia, arriving there at 7:25 P. M. It is evident that during the winter months this train makes both trips during lighting hours. The second train makes both runs in bright daylight. Each train has a connected lamp load of 37 amperes, is equipped with a 50-ampere generator and a 50-ampere storage battery. The conditions were so severe, however, that the batteries continued to fail and it finally became necessary to alternate the two trains every week; that is, change the train that had been running nights over to the day run. Since this change was made, perfect results have been obtained. In this case it is certain that a 100-ampere generator would have been necessary if it had been impossible to alternate the two trains.

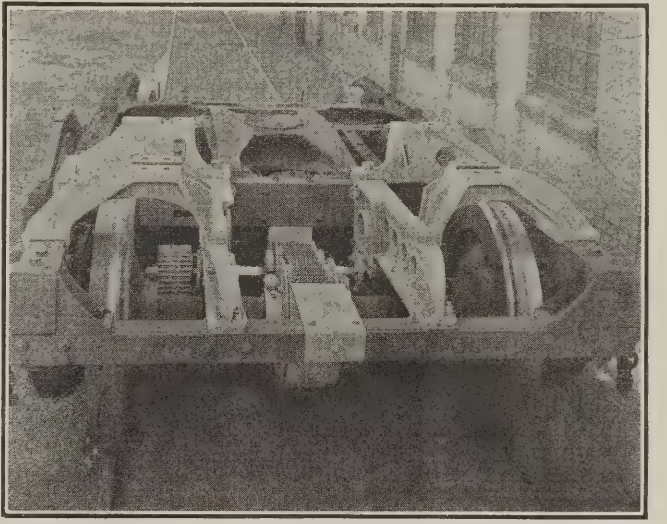


Fig. 5. Showing Method of Mounting Generator on Truck

Winnipeg Trains Nos. 13 and 14. Three equipments running between St. Paul and Winnipeg. Each train makes thirty regular stops in the 481 miles, and maintains a very fast schedule. No. 13 leaves St. Paul at 8:20 A. M. and arrives at Winnipeg at 11:20 P. M. the same day. No. 14 (the same equipment) leaves Winnipeg the next morning at 7:30 A. M. and arrives in St. Paul at 10:35 P. M. Half of each run is during daylight and half during lighting hours.

Each train has a connected lamp load of 50.5 amperes, is equipped with a 50-ampere generator and a 50-ampere storage battery. The storage battery capacity of these trains was originally 100 amperes (four 200-ampere-hour batteries). As each battery under these conditions would receive a charging current of only 12.5 amperes, the plates soon became badly sulphated and enlarged, resulting in numerous light failures. Three sets of 200-ampere-hour batteries were then tried with little better results. Finally another set was removed and since then the lighting on these trains has been entirely satisfactory.

Winnipeg Trains Nos. 19 and 20. Three equipments running between St. Paul and Winnipeg. Each train makes seventeen stops in the 481 miles, and, like the other Winnipeg train, maintains a fast schedule. No. 19 leaves St. Paul at 5:50 p. m., and arrives at Winnipeg at 9:15 a. m. No. 20 leaves Winnipeg at 5:15 p. m., and arrives in St. Paul at 8:30 a. m., both all night runs.

Each train has a connected lamp load of 113 amperes, and is equipped with a 250-ampere generator and a 75-ampere storage battery.

This train has been equipped for six months with the Gould Axle train lighter, and during that time has not had a light failure. The batteries have remained in excellent condition.

Conclusions.

1. In all cases the generator should have sufficient capacity to charge the batteries at their normal rate.

2. When train runs during lighting peak period only (4:30 to 11:00 p. m.), the normal discharge rate of the battery should equal the connected lamp load and the current capacity of the generator at 80 volts should be equal to 200% of the connected lamp load.

3. When train runs from early evening until late morning (6 p. m. to 8 a. m.), the normal discharge rate of the battery should equal at least 75% of the connected lamp load, and the current capacity of the generator should be approximately 150% of the connected lamp load. It is assumed in this case that during the lighting peak hours a floating charge only is given the batteries. Later when lamp load is reduced the batteries will receive a full charge at their normal rate.

4. When train runs over a period of half day and half night it should be equipped with a battery whose normal discharge rate is equal to at least 75% of the connected lamp load, and a generator whose current capacity at 80 volts equals the connected lamp load.

It is probable that further experiment will show that the battery capacity may be reduced for all of the above conditions, especially the last two.

Advantages of the Head-End Axle Generator System.

The advantages of the Unit Axle System of electric train lighting are:

1. Economy: Low cost of current with axle generation; elimination of wages paid to train electricians or whoever looks after steam head end set.
2. Train fully lighted at all times.
3. No terminal charging necessary.
4. Dynamo car can be anywhere in train.
5. Absence of excessive heat in baggage and express car.
6. Constant lamp voltage.
7. Current available at all times for lighting, heating, cooking, refrigeration, ventilation and electric cleaning.

We will now take up in detail several of the more important advantages:

ECONOMY: Following is a statement showing comparative costs of operating the steam head end system and the Unit Axle System on the Northern Pacific Railway.

	Steam Head End	Head End Axle
Current consumed per day (all cars), per actual check of electric lighted trains	1,300 KWH	1,300 KWH
Pounds of steam consumed by General Electric Company's turbine per KWH delivered, for average load, per actual test N. P. and C., B. & Q....	160 lbs.	
Pounds of steam consumed by axle generator per KWH delivered (average load), based on 40 lbs. of steam per drawbar HP (N. P. test), and 95% efficiency in chain drive......		59.5 lbs.
Total pounds of steam consumed per day for lighting of cars	208,000 lbs.	77,300 lbs.
Pounds of coal required per day for lighting of cars, based on 7 pounds of water evaporated per pound of coal (N. P. test)	29,700 lbs	11,042 lbs.
Cost of coal per day @ $3.00 per ton	$44.50	$16.56
Cost of coal per year @ $3.00 per ton	$16,300.00	$6,045.50
Wages per year:		
24 baggagemen @ $5.00 per month, 36 train electricians @ $85 per month	$38,160.00	
Total cost per year, fuel and wages	$54,460.00	$6,045.50
Cost of current production per KWH (fuel and wages above mentioned), ...	11.5c	1.27c
Actual saving per year in favor of head end axle light......		$48,414.50

The saving on other roads of course depends on the wages paid to train electricians and other details of operation, but in any case it would no doubt be considerable. This because the efficiency of the locomotive is approximately four times that of the turbine at one-third load and also because with the Unit Axle System all manual attention on the road is unnecessary. It has also proved unnecessary on the Northern Pacific to add local or terminal inspectors due to the use of this system. The men who have taken care of the steam head end sets have no trouble taking care of the unit axle machines. In fact, due to the fact that no terminal charging is necessary with the Unit Axle System, they have more time to spend on inspection of machines.

The saving in coal, which we find amounts to approximately one and one-half tons per night, not only effects a considerable money saving, but also makes it easier for the power to handle the trains in cold weather.

ABSENCE OF EXCESSIVE HEAT IN BAGGAGE AND EXPRESS CAR: This practically eliminates the claims for damages to baggage and express due to excessive heat and steam.

Our Claim Department advises that the total claims of this nature for the last twelve months amounted to $600. One claim alone, which amounted to $450, was for a trunk full of furs damaged by the heat and steam between Fargo, North Dakota, and Spokane, Washington.

We believe the other points of advantage are self-evident so will not take up the time of the convention by discussing them further.

In conclusion we wish to say that so far all the Unit Axle equipments have proved entirely satisfactory and we believe that the success of this system of electric train lighting is clearly established.

Respectfully submitted,

K. R. Hare, Chairman, Chief Elect., N. P. Ry. Co.
Jos. A. Andreucetti, Gen. For., C. & N. W. Ry.
C. R. Gilman, Chief Elect., C., M. & St. P. R. R.
J. J. Hack, Engr. Tr. Ltg. H. & V., So. Pac. Co.

Committee on Engineering Manual and Loose Leaf Binders

Your committee appointed to consider the subject of *Engineering Manual and Loose Leaf Binder* for same made a preliminary report at the June convention, at which time they requested a decision by the convention as to the size of the sheet which should be adopted. The convention took such action by a resolution to the effect that six-inch by nine-inch size should be used. Since that time the committee has been in correspondence on the subject, but wish to advise that they cannot make a definite report and would suggest that the committee be continued with the same personnel during the coming year.

Respectfully submitted,

J. R. Sloan, Penn. R. R.,
Chairman.

Committee on Illumination

The report of your committee for the year 1914 has been confined to the following:

1st—Completion of the report on the Day Coach Lighting Tests.

2nd—Investigation of special subjects referred to the Committee by the Executive Committee.

3rd—Illumination of classification yards.

4th—Resumé of recent developments in arc and incandescent lamps.

Day Coach Tests.

The report of the Day Coach Lighting Tests, of which a preliminary report was submitted at the last annual convention, has been completed and, with the engineering data derived from the tests, has been published under separate cover by the association. These tests, together with the Postal Car Lighting Tests previously made, furnish adequate data for the laying out of satisfactory systems of illumination for any of the general classes of passenger train cars.

Investigation of Special Subjects.

The Day Coach Tests brought out several features in passenger car illumination practice which it is highly desirable be standardized. As a consequence the association passed a motion at the last annual convention instructing that the following be investigated and reported upon at this meeting:

(a) Standardization of filament positions with reference to reflectors in car lighting service.

(b) Investigation and recommendation for the limiting screening angle of reflectors for car lighting.

(c) Further investigation of suitable lamp sizes in train lighting service, and in connection with that investigation to work in co-operation with the manufacturers.

A—Filament Position: Your committee would recommend the following sizes of shade holders and socket positions as standard for lighting fixtures to be used on passenger train cars:

Shade Holder	Distance End Contact of Electric Lamp to be Above Top Edge of Reflector
2¼"	1⅛" ½" 0"
4½"	1"

This provides three lamp positions for the 2¼" holder and one for the 4½" holder. Investigation has shown that this will provide for practically all types of reflectors or shades in general use in car lighting where used with the standard G-18½ or G-30 train lighting lamp. With certain of the postal car lighting units, however, other positions are required to give the proper distribution of light. However, most of the designs of postal car lighting fixtures are such that the socket position can be changed at little expense. The important application of these proposed standard locations is for those designs of fixtures where the relative location of fixture and reflector cannot be changed except by replacing the fixture or by expensive alterations. It is hoped that the fixture manufacturers, reflector manufacturers and railway engineers will co-operate in establishing these positions as standard.

B—Screen Angle: Your committee recommends 65 degrees as the limiting screening angle of reflectors in car lighting service, i e., no portion of the bare lamp filament or bare mantle should be visible to the eye when the unit is observed at an angle of 65 degrees or greater from the nadir.

C—Lamp Sizes: The question of standardization of lamp sizes for train lighting service was referred to special committee, preliminary report of which was made at the June Convention and final report at this convention.

It is recommended that the Association act upon these through the regular channel for adoption as standard.

Illumination of Classification Yards.

The satisfactory and economical lighting of track scales and classification yards is one of the most important as well as difficult problems in the field of railway lighting. On account of its importance and the fact that there is little reliable data on the subject your Committee decided to devote practically its entire efforts to the investigation of this problem. Conditions arose, however, which made it impossible to carry out this year the experimental test work that had been planned. This report is therefore in the nature of a progress report and has been confined to a description of the problems to be solved, the Committee deeming it inadvisable to present the preliminary data thus far obtained until a complete report of the subject can be submitted. It is recommended that the succeeding Committee on Illumination continue the investigation of this subject.

The track scale and the classification yard are so closely associated and the successful operation of either is so much dependent upon the other, that the lighting of both should be treated as one problem. The track scale is responsible for the larger portion of every railroad's income. Fairness to the shipper demands that every precaution be taken to insure correct weights. The classification yard is responsible for probably more demage to rolling stock and loads, than any other one item in railroad operation. This item of expense can be reduced to some extent and the movement of freight may be facilitated by the proper lighting of the yard at night.

Attempts have been made, during the past few years, to solve this problem. These efforts have not always been successful due largely to an improper conception of the problem. For the benefit of at least those illuminating engineers who do not have the advantage of railroad training, a brief recital of the track scale and classification yard problem may be of interest.

The classification yard is the point where freight in car load quantities, is collected together for weighing and classifying so that it may be made up into train loads for shipment to or near its final destination. As practically all modern classification yards are of the gravity operated type it will be the only one considered in what follows.

Train loads are hauled by road locomotives into what is known as the receiving yard. The tracks in the receiving yard are graded towards the scale. Immediately before the scale is reached there is a short sharp raise in the track with another drop to the scale. This is known as the "hump." The grade of the tracks in the receiving yard is such that the weight of a train load, acting upon the incline is sufficient to push the last car over the hump. It is only necessary then to attach a pusher locomotive to the rear end of a draft of cars to regulate their speed as they move towards the scale. Comparatively little manual labor is performed in the receiving yard so that only sufficient light to permit the coupling of the locomotive and the release of the hand brakes on the cars, is necessary at this point.

The hump is so proportioned as to elevation, grade, and distance from the scale platform, that all cars, regardless of size, weight or condition, will move across the scale platform in approximately the same length of time. As the car moves across the hump there is some point where the coupler is neither in compression or tension. At this point it is cut loose from the draft. As it moves towards the scale an inspection is made of the running gear and brake rigging, requiring well diffused light of comparatively high intensity under the car. A good many men are employed in this vicinity so that the ground space must be as open and free as possible. Ordinarily the lighting must be provided from one pole placed some distance from the center of the track. In several instances the ground in this vicinity has been covered with crushed oyster shells to provide a white reflecting surface to throw light under the car.

As the car moves over the scale the weigh master checks the initials, number and light weight of the car with the notation on the lading card in his possession. The weigh master has three chances to make this identification; on the end of the car as it approaches, on the side of the car as it passes, and again on the opposite end as it leaves the scale. As time is limited the identification must be made quickly, requiring a comparatively high intensity of illumination. The lamps must not be placed within the range of vision of the weigh master. As the car moves across the scale platform it must be weighed. Ordinarily there is about ten seconds available for this operation, necessitating well diffused lighting of fairly high intensity within the scale house. No direct light must strike the weigh master's eye nor must any light be reflected from the glass window in front and at the ends of the scale beams, to obstruct his view. The numbers on the scale beam must be clearly and sharply defined for quick and accurate reading and the small table or stand holding the manifests, etc., must be well lighted.

After the car has left the scale, the car rider climbs on to ride the car into the classification yard proper. At times it is necessary for the weigh master to note the name of the rider on the car. This requires that sufficient light be provided for the rider to mount the car safely and it must be so distributed as to enable the weigh master to quickly identify the rider. As the car moves into the yard the rider must observe the location of other cars on the track, and as he judges the interval between cars, he must reduce the speed to that only sufficient to couple the cars as they come together. With the great variety of cars that it is possible to have in a yard, varying in height from five to fifteen feet or more, and in color from white to black, this is a difficult and dangerous operation unless the yard is well lighted. When the car has been placed on the proper track the rider must thread his way over and around other cars, across the yard to the side where he is picked up by a locomotive and specially designed car and carried back to the scale house, or where no such facilities are provided must walk back through the yard. This crossing the yard is both difficult and dangerous and requires that the space between cars must be well lighted.

Classification yards may vary in width from two or three tracks to three or four and sometimes five hundred feet, and in length may extend several miles. The value of the ground is often so high that space cannot be provided through the center of the yard for a pole line, thus seriously handicapping obtaining the best location for lighting units. In many locations owing to constantly changing traffic conditions the yard may be more or less frequently changed as to size and shape, so that under normal conditions the lighting installation cannot be expected to remain in a fixed location more than a few years, thus making a cheap construction desirable.

The lighting of classification yards is not a question of lighting an open space though many have treated the problem as such. It is rather essentially that of street lighting in a city of tall buildings and very narrow streets where the lamps must be spaced at least twice the height of the buildings. For ideal illumination the conditions to be met are as follows:

(a) Illumination of the grade leading from the scale to the yard.

(b) Illumination of the switches at the head of the yard to facilitate control of car movement from the switch tower.

(c) Illumination of every track irrespective of the adjacent car.

(d) Illumination of every car in the yard.

(e) Absence of glare from every position in the yard.

To what extent these can be satisfied practically and the best means for doing so is left to subsequent investigation. Another factor making it difficult to make definite recommendations at this time for types of lighting units best suited for yard lighting is the rapid change now taking place in the art of tungsten lamp manufacture.

Recent Developments in Arc Lamps.

In view of the recent extensive development in the various types of lighting units it is thought that a brief resume of the more important would be of value. While with the introduction of high efficiency high candle-power tungsten lamps your Committee believes that incandescent lighting will eventually supersede arc lighting in the railway field with the possible exception of a few special cases, the improvements being made in the arc lamp should not be overlooked. For the past year these can be summed up as follows, being confined largely to the luminous arc lamp:

(A)—A new negative electrode for luminous arc lamps giving an increased candle-power, amounting to over 50% without increasing wattage, and consequent increased efficiency.

(B)—Further increasing the candle-power at ten degrees below the horizontal by the use of a prismatic refractor.

(C)—Development of a low wattage ornamental luminous arc lamp for boulevards, parkways and residential streets.

(D)—Further beautifying the external design of the ornamental luminous arc lamp and reduction of intrinsic brilliancy to a minimum.

(E)—Standardization of a 5 ampere DC Series circuit for luminous arc system.

(F)—An enclosed flame carbon arc lamp for AC series circuits operating without shunt coils, cutouts, and starting resistance.

On account of the excellent distribution of light for illumination of large areas, obtained by use of refractors, a brief description of this is of interest:

By use of a prismatic refractor the rays of light which otherwise would be lost are redirected to an angle of 10° below the horizontal, thus increasing at this particular angle the candle-power about three times that obtained with the standard electrode in the present lamp. Using the refractor in connection with the high efficiency electrode gives at the maximum angle for a wattage input of 310 watts, 1,750 candle-power, thus making this arc lamp more efficient for the lighting of large areas than any other illuminant now on the market.

This refractor consists of two pieces of prismatic glass connected together at the top and bottom, the prisms being on the inside so as to present a smooth surface to the weather. The refractor which surrounds the electrode is mounted so as to catch the light rays that pass out horizontally or above, and redirect them.

Table I gives the principal engineering data for practically all types of arc lamps in general use. This data has been furnished by the arc lamp manufacturers and presumably is based upon results obtained under laboratory test conditions. As to what extent these results would be modified under service conditions your Committee has not had opportunity to investigate. Figure 1 shows the photometric curves of a standard 4 ampere luminous arc lamp with (a) standard electrode, (b) new high efficiency electrode, and (c) high efficiency electrode with prismatic refractor.

Recent Developments in Incandescent Lamps.

In the incandescent lamp field the most important improvements have been made in the development of the high candle-power high efficiency mazda lamp. So much has been published recently in the proceedings of various associations, the technical press, and the data books of lamp manufacturers pertaining to gas filled lamps that your Committee felt it was unnecessary to devote any space to description of their properties or to presenting the usual engineering data, but has confined the report to some of the features that are apt to be overlooked.

In comparing the efficiencies of various types of illuminants special attention should be given to the bases on which the efficiencies are determined. The efficiencies given in Table I of arc lamps are based on the mean spherical candle-power (also mean hemispherical) of the lamps as equipped for service, thus including losses of reflectors, enclosing glassware, etc. Efficiencies as usually given for incandescent lamps are based on mean horizontal candlepower and therefore must be reduced by the reduction factor of the lamp as well as the efficiency of the con-

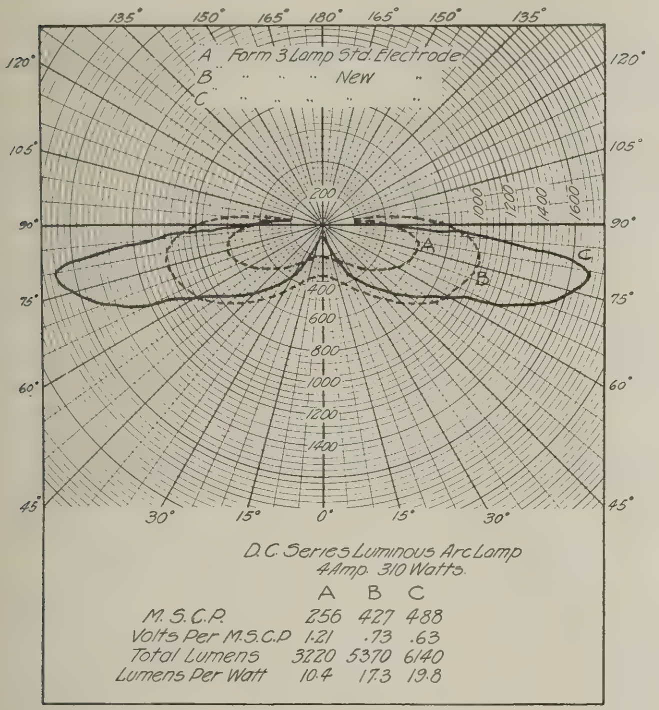
TABLE I

ARC LAMP DATA

	Enclosed Carbon Arc Lamp.	Enclosed Carbon Arc Lamp.	Enclosed Carbon Arc Lamp.	Luminous Arc Lamp.	Luminous Arc Lamp.	Luminous Arc Lamp.	Luminous Arc Lamp †Refractor.	Luminous Arc Lamp.	Luminous Arc Lamp.	Luminous Arc Lamp.	Luminous Arc Lamp.	Enclosed Flame Arc Lamp
D. C. or A. C....	D.C.	A.C.	A.C.	D.C.	D.C.	D.C.	D.C.	D.C.	D.C.	D.C.	D.C.	D.C.
Amperes........	6.6	6.6	7.5	4	4	4	4	5	5	6.6	6.6	9.6
Watts..........	480	430	480	310	310	310	310	388	388	510	528	480
Globe..........	Clear	Clear	Clear	Clear	Clear	Alba	Clear	Clear	Alba	Clear	Clear	Clear
Electrode.......	.....	.....	.....	St'd	Hi.Ef	Hi.Ef	Hi.Ef	Hi.Ef	Hi.Ef	St'd	Hi.Ef	......
Color Carton...	.....	.....	.....	....	.....	.....	.....	.....	.....	.....	.....	White
Life—Hours....	100	100	90	175	150	150	150	125	125	100	80	120
M. S. C. P.....	281	140	173	256	427	328	488	637	568	668	871	1091
Watts/M.S.C.P.	1 71	3.07	2.77	1.21	.73	.95	.63	.61	.68	.76	.61	.44
M. H. S. C. P...	453	238	291	488	814	450	910	1131	770	1266	1693	2022
Watts/M. H. S. C. P.......	1.03	1.81	1.65	.63	.38	.69	.34	.34	.51	.40	.31	.24
Total Lumens...	3530	1760	2175	3220	5370	4120	6140	8000	7140	8400	10950	13720
Lumens/Watt...	7.3	4.1	4.5	10 4	17.3	13.3	19.8	20.6	18.4	16.5	20.7	28.6
Lumens 0°—90°.	2850	1496	1830	3065	5120	2825	5720	7110	4840	7960	10640	12720
Lumens 0° / 90°/Watt	5.9	3.5	3.8	9.9	16.5	9.1	18.5	18.3	12.5	15.6	20.2	26.5
Lumens 0°—60°.	1665	785	855	1178	2040	1807	1695	3276	2215	3605	6174	6174
Lumens 0° / 60°/Watt	3.5	1.8	1.8	3.8	6.6	5.8	5.5	8.4	5.7	7.1	11.6	12.9

	Enclosed Flame Arc Lamp.	Enclosed Flame Arc Lamp.	Enclosed Flame Arc Lamp.	Enclosed Flame Arc Lamp.	Enclosed Flame Arc Lamp.	Enclosed Flame Arc Lamp.	Enclosed Flame Arc Lamp.	Multiple Enclosed Flame Arc Lamp.	Multiple Enclosed Flame Arc Lamp.	Multiple Enclosed Flame Arc Lamp.	Multiple Enclosed Flame Arc Lamp.	Multiple Enclosed Flame Arc Lamp.	Multiple Enclosed Flame Arc Lamp.
D. C. or A. C....	D.C.	D.C.	D.C.	A.C.	A.C.	A.C.	A.C.	D. C.	A.C.	A.C.	D. C.	A.C.	A.C.
Amperes........	9.6	9.6	9.6	7.5/10	7.5/10	7.5/10	7.5/10	6.5	7.5/10	7.5/10	6.5	7.5/10	7.5/10
Watts..........	480	480	480	465	465	465	465	7.15	540	540	715	540	540
Globe..........	Clear	Carrara	Carrara	Clear	Clear	Alba	Alba	Clear	Clear	Clear	Clear	Clear	Clear
Electrode.......	......	......	......	......	......	......	......	......	......	......	......	......	......
Color Carton...	Yellow	White	Yellow	White	Yellow	White	Yellow	Yellow	White	Yellow	Yellow	White	Yellow
Life—Hours....	120	120	120	120	120	120	120	120	120	120	120	120	120
								Intens	ive Re	flect or	Exten	sive R	eflector
M. S. C. P.....	1297	831	1073	794	917	685	828	867	482	535	805	445	495
Watts/M.S.C.P.	.37	.58	.45	.59	.51	.68	.56	.83	1.12	1.01	.89	1.21	1.09
M. H. S. C. P...	2367	1222	1598	1329	1525	917	1115	1733	965	1070	1610	893	993
Watts/M. H. S. C. P.......	.20	.39	.30	.35	.31	.51	.42	.41	.56	.51	.44	.605	.54
Total Lumens...	16300	10450	13500	10000	11500	8500	10400	10890	6060	6730	10110	5620	6250
Lumens/Watt...	34.0	21.8	28.8	21.4	24.8	18.5	22.3	15.2	14.2	12.5	14.2	10.4	11.6
Lumens 0°—90°.	14900	7700	10050	8350	9580	5760	7000	10890	6060	6730	10110	5620	6250
Lumens 0° / 90°/Watt	31.0	16.0	20.9	18.0	20.6	12.4	15.0	15.2	11.2	12.5	14.2	10.4	11.6
Lumens 0°—60°.	7095	4230	5240	3460	4340	2790	3400	9950	......	......	9220	......	......
Lumens 0° / 60°/Watt	14.8	8.8	10.9	7.5	9.3	6.0	7.3	13.9	......	......	12.9	......	......

tainer to place them on a comparable basis. With the larger sizes of multiple gas filled mazda lamps it should be noted that the reduction feature is approximately 90% as contrasted with about 78% for the other mazda lamps. Expressed in another way this means that, in comparing the lamps on a horizontal candle-power basis, for the same candle-power in each case the total light flux of the improved lamp is 90% compared with 78% for the other class.



Distribution Curves of the Three Types of Arc Lamps.

The question of ventilation of the lighting unit with the larger sizes of gas filled lamps is a matter which has been given considerable attention. The service performance data thus far obtained has been insufficient to determine how important a bearing this feature has upon the life of the lamp, but present experience seems to indicate that its detrimental defects have been overestimated. It would seem desirable, however, that with enclosing types of units used in interior lighting, ample ventilation should be provided to prevent excessive heating of the container itself. With outdoor lighting, especially where open types of reflectors are used, or with smaller sizes of lamps, it would appear that special means of ventilation are not required as far as the lamp itself is concerned but may be necessary to prevent the container from overheating.

It is hardly necessary to state that on account of the high intrinsic brilliancy of the gas filled lamps that wherever used in the direct line of vision either enclosing globe or indirect unit should be employed. Where used with an open type reflector the lamp should be mounted high so as to be out of direct line of vision.

As to the life performance of this class of lamp little reliable data is as yet available of the service obtained in the railway field. Data which has been compiled is of such fragmentary character and so little is known of the exact conditions under which the lamps are operating that no great reliance can be placed upon it. It should also be realized that the development of the manufacture of these lamps has been rapid and consequently much of the information that has been obtained is based on the performance of the earlier lamps. In general it can be said that the performance of the series lamps has been much better than the multiple lamps, the data indicating that about 5% have failed during the first 300 hours and something less than 20% during 1,000 hours. The reports of the earlier installations of multiple lamps have shown widely varying results, in some cases being very poor and others exceptionally good. The causes of these failures, however, have to a large extent been ascertained and the necessary steps taken to remedy them. With the improvements that have been made in the past few months in obtaining more uniform life performance of gas filled lamps as well as that which can be expected in the coming months your Committee feels that there should be no hesitancy in adopting this type of lamp as far as life performance is concerned, especially in view of the fact that the manufacturers have guaranteed the average life performance of 1,000 hours for multiple lamps and 1,350 hours for series lamps where the conditions of operation are known to be satisfactory.

Respectfully submitted,
L. S. Billau, B. & O., Chairman.
J. L. Minick, Penn. R. R.
H. C. Meloy, L. S. & M. S. Ry.
L. Schepmoes, Safety C. H. & L. Co.
D. P. Morrison, P. & L. E.
W. H. Rolinson, Westinghouse Lamp Co.
Preston S. Millar, Elec. Test Laboratories.
C. W. Bender, Natl. Lamp Wks. of G. E. Co.

Committee on Industrial Trucks

Your Committee, appointed to consider the subject of industrial trucks to make definite recommendations for standards in regard thereto, begs to present the following report:

The Committee considered the following phases of industrial trucks: Capacity, speed, voltage, motors and batteries, tires and wheel sizes.

The Committee had the co-operation of the following gentlemen:

Mr. Wm. C. Carr, president, Automatic Transportation Co.
Mr. T. M. Ford, New York rep., Automatic Transportation Co.
Mr. H. E. Heath, consulting engineer, Hoagland-Thayer, Inc.
Mr. F. E. Fisher, electrical engr., Diehl Manufacturing Company.
Mr. A. Parkhurst, engineering dept., General Electirc Company.
Mr. F. E. Murphy, C. W. Hunt Company, Ind.
Mr. W. W. White. General Vehicle Company.
Mr. F. E. Queeney, engineering dept., General Vehicle Company.
Mr. F. S. Gassaway, Willard Storage Battery Company.
Mr. R. L. Heberling, Philadelphia Storage Battery Co.
Mr. L. H. Flanders, Electric Storage Battery Company.
Mr. C. J. Welch, asst. to dist. mgr., United States Tire Company.
Mr. T. A. Aspell, the B. F. Goodrich Company.
Mr. Drew McKenna, the B. F. Goodrich Company.
Mr. E. B. Lausier, Timkin Roller Bearing Company.
Mr. Schoepf, the Westinghouse Elec. & Mfg. Co.

The Committee held meetings on September 4th at Altoona, and September 18th at New York. Synopsis of the minutes of these two meetings will be found in appendix Exhibit "A" and "B."

Capacity.

Your Committee recommends as standard a capacity of 4,000 lbs. for industrial trucks.

This rating is practically standard with nearly all of the industrial truck manufacturers and the rating has been worked over after many years' experience with hundreds of trucks. A lading of 4,000 lbs. is as great as can be handled with safety and economy within the confined conditions prevailing in passenger and freight stations, and shop enclosures. A lower rating is not considered advisable for the reason that experience indicates that industrial trucks are generally loaded to about 4,000 lbs. or slightly in excess of that figure and this condition would result in trucks being over-loaded provided they were designed for ratings less than 4,000 lbs.

Speed.

Your Committee recommends as standard a speed of 5 miles an hour with loaded truck for general railroad service. The Committee also recommends an alternative speed of 7 miles an hour for operation under special conditions where runs are comparatively long and runways free from other workmen.

The subject of speed was discussed quite freely and it is believed that the above recommendations for 5 miles an hour for general service is the most appropriate speed for service in baggage departments, shops, under ordinary conditions and the general type of freight stations. The higher speed of 7 miles an hour permits of certain economies where the runs are particularly long, where the shops are located at a distance from each other and in long runs in dock service.

Tires and Wheel Sizes.

Your Committee recommends the following standards for tires and wheel sizes for industrial trucks:

Nominal Size	Width	Actual Inside Diam. of Tire	Corresponding Outside Diam. of Wheel	Width of Finished Wheel
10 in.	3 in. Dual	6.255 Max. 6.250 Min.	Optional with truck maker	Not less than 6 in.
16 in.	3½ in.	12.120 Max. 12.115 Min.	12.135 Max. 12.130 Min.	3½ in.
20 in.	3½ in.	15.995 Max. 15.990 Min.	16.010 Max. 16.005 Min.	3½ in.
22 in.	3½ in.	17.745 Max. 17.740 Min.	17.760 Max. 17.755 Min.	3½ in.
27 in.	3½ in.	23.495 Max. 23.490 Min.	23.510 Max. 23.505 Min.	3½ in.

Depth of tread on all sizes not over 2 in.

In making the above recommendations your Committee believes that it is far better practice to decide on tire standards from the sizes already in existence, other things being equal, and to adopt a standard that will give good results and which have been used in the greatest quantity.

Your Committee also recommends that the pressed on steel base type of tire be considered standard and that the tread depth be limited to 2″.

There is at present a wide range in tire practice among manufacturers of industrial trucks, your Committee having found 31 sizes between 10″ and 27″ in diameter. The Committee's recommendations reduce this number to 5. The principle reason for this diversity of sizes is in the various depths of tread now existing. Your Committee has found that the 2″ depth of tread lasts from one to four years, depending upon the character of service, and after two or three years of service generally fail from age. Your Committee believes therefore that the 2″ depth of tire made up from a high quality compound which reduces the rolling resistance and cost of truck and battery maintenance is therefore preferable to a deeper tread which to sell at the same price must be made of poorer quality of rubber which would increase the rolling resistance and cost of operation of the trucks.

Voltage.

Your Committee recommends as standard a potential of 24 volts for general industrial truck service. The Committee also recommends that the battery consist of either 12 cells of lead battery with jar sizes $5\frac{13}{16}$″ x $6\frac{3}{16}$″ with high bridge and with $\frac{5}{32}$″ wall, and the recommendations for Edison battery are 21 A-6 cells assembled in 3 trays of 7 cells each. The Committee also recommends that the voltage of the motor be rated at 24 volts.

The subject of voltage, batteries and motor was quite freely discussed at the meetings of the Committee, as will be noted in the minutes of the meetings found in the appendix and the above recommendations are made from the experience of a large majority of industrial trucks in actual service. Trucks of this voltage have given satisfactory service for many years and it is believed by the Committee that this represents the best compromise possible. Some of the visitors, however, at the Committee meetings favored higher voltage, 36 and 48 volts being suggested on account of slightly better efficiencies in the motor, and 85 volts with lead battery and 60 volts with Edison battery to facilitate charging directly from 110-volt direct current circuits. In regard to the 36 and 48 volts suggested, the advantages in the motor is more than offset by the greater cost and less substantial construction in the battery and inasmuch as the battery is an item that is replaced at frequent intervals your Committee feels that it should be given more consideration than the motor. The 60 and 85-volt standards have much in their favor where the trucks are used in small quantities and where 110-volt direct current is available. There is no advantage as regards charging at this voltage where trucks are used in quantities of 6 or more and the disadvantages as regards more fragil battery are serious.

The Committee requests that a decision on voltage be submitted to the Association for ballot to decide as between 24, 36, 48 and 85. The advantages as regards interchangeability of motors with various manufacturers are available only in case the lower voltages of 24 or 36 are decided upon for the reason that if higher voltage would be adopted an 85-volt motor is necessary for lead battery and 60-volt motor for Edison battery.

General.

When the Association decides on a standard voltage, your Committee can take up the question of motor outline and approximate design, the design being carried out in sufficient detail so that a standard industrial truck motor could be carried in stock by motor manufacturers. At the present time motors are being built for a wide range of voltages varying from 20 to 85, and the small quantity of each variation which can be used necessarily keeps up the price. Your Committee feels that in addition to obtaining interchangeability of motors the cost could be materially reduced by adopting a standard motor and it is recommended that the Committee be continued for this purpose.

Your Committee further advises that an advisory committee on industrial truck standards has been appointed by the Society of Automobile Engineers consisting of the following members:

Mr. C. E. F. Ahlm.
Mr. R. A. Bachman.
Mr. T. V. Buckwalter.
Mr. A. H. Gfrorer.
Mr. J. E. Hale.
Mr. H. G. McComb.
Mr. R. J. Nightingale.

An effort will be made to co-operate with this advisory committee in the matter of industrial truck standards.

Respectfully submitted.

Mr. C. E. F. Ahlm.
Mr. F. K. Fildes.
Mr. A. H. Gfrorer.
Mr. J. E. Hale.
Mr. H. G. Thompson.
Dr. W. E. Winship.
Mr. T. V. Buckwalter,
Chairman.

Committee on Standards

Your committee held a joint meeting with the representatives of the Consolidated Electrical Railway & Equipment Co., the Electric Storage Battery Co., the Gould Coupler Co., the Safety Car Lighting & Heating Co. and the United States Light & Heating Co., at Jersey City, September 10, 1914, four of the five members of the committee on standards being present.

The committee thought it best to confine the business of the meeting to three subjects—axle pulleys, generator pulleys and generator pulley fits on armature shafts.

It was the unanimous opinion of the gentlemen present that the following recommendations be submitted to the association for such action as you may wish to take.

The committee wishes to emphasize particularly the necessity of establishing standards for generator pulleys. At the present time there are more than 20 different types of generator pulleys, and more than 10 different pulley fits. The committee therefore submits drawings showing two diameters of pulleys, and drawing of generator pulley fit on armature shaft. If these recommendations are made standard practice only two sizes of pulley need be manufactured and carried in stock for any type of generator—thereby making a substantial saving in the cost of production, as well as in maintenance. The committee has also made recommendations in regard to axle pulleys—the twenty-one-inch pulley being the same as shown in last year's proceedings, but have thought it best to change the type and dimensions of the smaller pulley from 17 inches to 16 inches in diameter, omitting the flangeless pulley and substituting a flanged pulley, same face as the twenty-one-inch pulley.

The subject of taper fit for the generator pulley has been the subject of much discussion. Your committee, as well as the representatives of the manufacturers, unanimously recommended the ¾-inch taper in 12-inch total—as the most desirable. At the present time over 75 per cent of the equipments in service have the ¾-inch taper fit. From a mechanical standpoint it is better than 1½-inch taper.

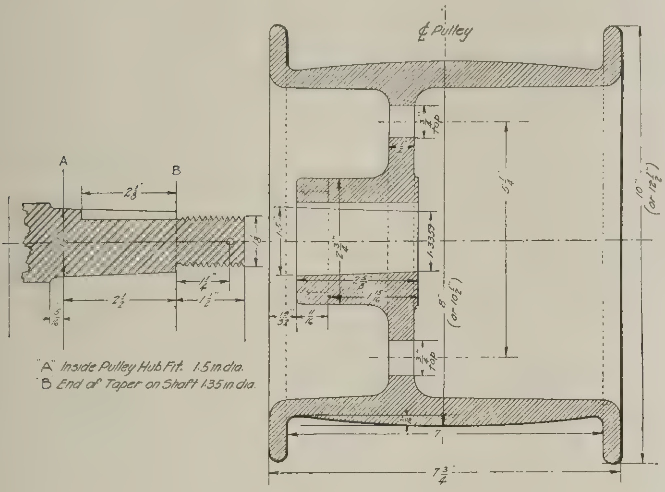
Axle Pulleys.

It is recommended for standard practice that two sizes of axle pulleys be used. The larger pulley to have a maximum diameter of 21 inches measured on face, and the other pulley 16-inch diameter measured on face. Both pulleys to have 1-inch external width of flange, 7½-inch straight bore, 8-inch width of flat face, between flanges, and length of hub 6½ inches bored straight.

If for any reason the 21-inch maximum diameter of pulley cannot be used with the 10½-inch diameter of generator pulley, than the 16-inch axle pulley should be used with the 8-inch generator pulley, thus preserving the ratio of 2 to 1.

Generator Pulley.

It is recommended that two sizes of generator pulleys be used the large pulley to be 10½ inches diameter, and the smaller pulley to be 8 inches diameter, both measured on crown of the face. Both pulleys to have ⅜-inch crown measured on diameter, also 1-inch external flange and 7-inch face between flanges; length of hub 2⅝ inches. The clearance distance between long end of the hub and the same end of the pulley must not exceed 19/32 of an inch.



Standard Generator Pulley.

The bore of the generator pulley to have a taper of ¾ inches in 12-inch total; largest diameter 1.5 inches, smallest diameter 1.3359 inches, length of taper 2⅝ inches on center line.

Taper Fit on Armature Shafts.

Taper ¾-inch in 12-inch total.
Length of taper 2 15/16 inches on center line.
Diameter at small end, 1.35 inches.
Diameter 2½ inches from end, 1½ inches.
Width of keyway ⅜ inch.

The diameter of 1½ inches to be so located that when a standard pulley is applied, either 10½ or 8-inch diameter, not less than ⅜-inch clearance shall be provided between the pulley flanges and any part of the generator head.

That portion of the thread on the armature shaft for the reception of a nut, to hold the pulley in place, should be cut away to allow the nut to impinge on the end of the taper fit. The threaded pulley end to be for either 1-inch or 1⅛-inch nut, with U. S. standard threads, not less than 1½ inches long over all, and a threaded portion not less than 1 1/16 inches long, with a hole not less than 5/32 inch, located 1¼ inches from the end of taper fit, for the reception of a cotter key.

If all of the above recommendations are made standard practice, a standard pulley can be applied to any make of generator.

In closing this report, the committee wishes to call attention to the fact that the truck builders with few exceptions have not taken into consideration the application of axle generators or pulleys to axles or trucks. The above recommendations in regard to sizes of pulleys should enable them to so design their trucks to give ample belt clearance. The great loss of belts is primarily due to truck design and brake beams. If this can be corrected, much money can be saved by the railroads on this one item.

The committee wishes to go on record as being in favor of the Clasp Type of brake, or some design of inside hung brake beam, to give proper belt clearances.

J. H. Davis, Elec. Engr., B. & O. R. R.
E. W. Jansen, Elec. Engr., Ill. Cent. Ry.
Ward Barnum, Elec. Engr., Lt. & N. Ry.
C. H. Quinn, Elec. Engr., Norfolk & West. Ry.
D. J. Cartwright, Chairman, Lehigh Valley R. R.

Committee on Outside Construction and Yard Lighting

Your committee submitted a progress report at the last annual convention and now offers for your consideration a more complete report on outside construction. We have, however, not made any further investigation or report regarding yard lighting, as your Committee on Illumination suggested that as they had been offered facilities for making an investigation on yard lighting, that it would be best for them to take up this portion of the work, and as this committee had no special opportunity to make an investigation of this character, we are very glad to accept the kind offer of the Committee on Illumination.

Outside Construction--Overhead--Poles

General.

On account of local conditions or in order to conform to certain architectural features, concrete or steel poles should probably be used in some instances, although a sawed wooden pole would, in most cases, answer the requirements in this respect.

Where long spans are necessary, steel structures would probably offer the greatest advantage.

Pole construction should closely follow the rules of the National Electrical Code and meet the requirements of local or state laws and standard specifications of Railroad Co.'s Wire crossing over tracks to conform with standard specifications of the National Electric Light Association and Railroad Co.'s.

Recommend the marking of all poles in railroad yards with the words "SAFETY FIRST."

Spacing.

When in a straight line and under ordinary conditions, the spacing of poles should not greatly exceed 125 feet.

For curves the following spacings are recommended.

Amount of Pull—Ft.	First Class Lines—Ft.
1 to 5	120
5 to 10	110
10 to 15	100
15 to 25	90
20 to 25	80
25 feet and over	70

At line terminals and at corners the last space should not be over 60 feet.

Setting.

If possible, poles should be set the same day hole is dug. When this is not practicable, the hole must be securely covered and properly lighted to prevent accidents.

Poles should be set to the depth given in the following table:

Length of Poles—Ft.	Depth on Straight Lines—Ft.	Depth on Curves and Soft Ground—Ft.	Depth in Rock—Ft.
30	5	6	3½
35	5½	6	4
40	6	6½	4
45	6	6½	4½
50	6½	7	4½
55	7	7	5
60	7	7½	5

Where the pole is set in a sloping bank, the depth should be measured from the lowest side of the opening. Where the slope is greater than forty-five (45) degrees or where the bank is so soft that the pole is liable to kick out, the pole should be set as much deeper than specified in the above table, as is deemed practicable.

Where there is a possibility of the grade being changed, allowances should be made, if practicable, so that the poles will be at their proper height when the correct grade is established.

In general, crooked or curved poles subjected to unequal stresses should be set so that the strain will tend to straighten the pole. For example, crooked or curved poles at the end of pole leads or at long spans should be set with the concave side away from the greater load.

The holes should be large enough to permit the free entrance of the poles without hewing or stabbing and should be full side at the bottom, so as to admit of the use of tampers. Where poles or stubs are ground braced, the excavations should be of sufficient size to contain the ground brace hereinafter specified.

In setting poles, the dirt should be filled in evenly around the pole and thoroughly tamped as the hole is filled.

After the pole is placed in position, only one shovel should be used in filling the hole. Three tampers should be employed continuously to pack in the filling until the hole is completely filled. Soil should then be piled up about 6 in. above the surface and firmly packed aound the pole.

In filling holes, the coarse soil or gravel should be used at the top of the hole. Rock must be firmly wedged in around poles that are set in solid rock.

In difficult situations, particularly in soft ground where stability cannot be otherwise obtained, an extra heavy pole should be used and it should be set in concrete and braced below the ground line with logs or pieces of old "T" rails about 5 or 6 ft. long. This kind of construction should not be used except where other forms of construction are impossible.

Poles should ordinarily be set vertically and carefully lined up. Corner poles and poles at the ends of leads should be pulled over after they are set, so that after the wires have been pulled taut 25 and 30-ft. poles will have a take of approximately 1 ft.; 35-ft. or taller poles, 18 in.

Clearance.

The minimum clearance from gage line of rail to pole should not be less than 5 ft. 8 in., and all overhead lines, when crossing tracks, should have a clearance from top rail of not less than 25 ft., 30 ft. if practicable.

Guying.

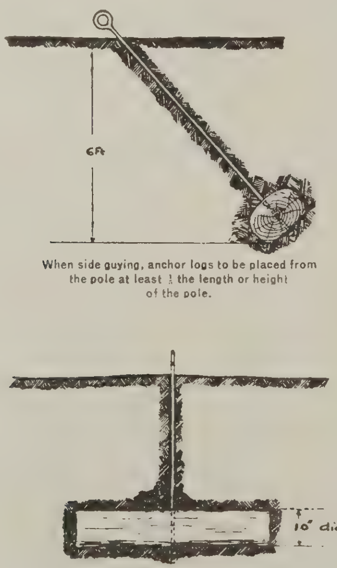
Where anchor logs are used for guying the following is recommended:

Anchor logs should be of good sound timber, cross-ties or their equivalent, and their dimensions should correspond to the depth of excavation called for in the following table:

Dimensions of Anchor Logs

Depth of Excavation—Ft.	Length, Feet.	Diameter, Inches
6	5	10
6	7	7
5	5	16
5	8	10
4	5	23
4	8	14
4	10	12

The hole should be so dug that the log will pull against a shoulder of solid earth and where necessary more than one guy should be used. (See Fig. 1.) The hole should be filled with rock and solid earth and well tamped.



When side guying, anchor logs to be placed from the pole at least ½ the length or height of the pole.

Fig. 1. Setting of Anchor Logs

Special devices for anchoring may be used, where the soil conditions require it.

The anchor log should be bored and the guy rod attached to same by a nut and washer: The side of the hole should be dug out so that the guy rod will lean toward the pole. (See Fig. 2.)

Where it is necessary to set a guy in a solid rock, galvanized iron rock eye bolts, as shown in Fig. 3, may be used.

The ends of all guy wires should be wrapped twice about the pole overlapping itself and fastened with one or more guy clamps, and this wrapping should be held in place on

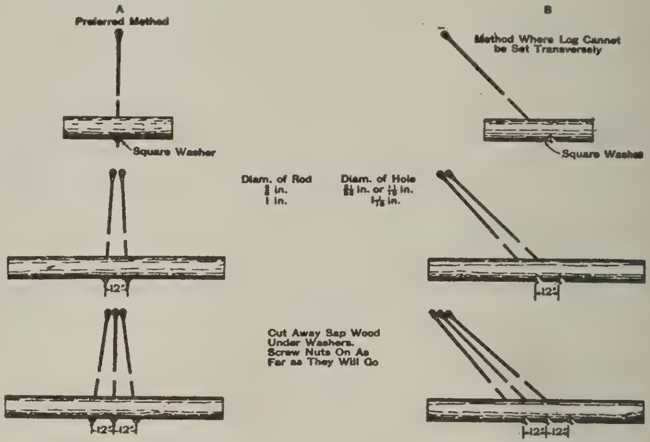


Fig. 2. Framing Anchor Logs

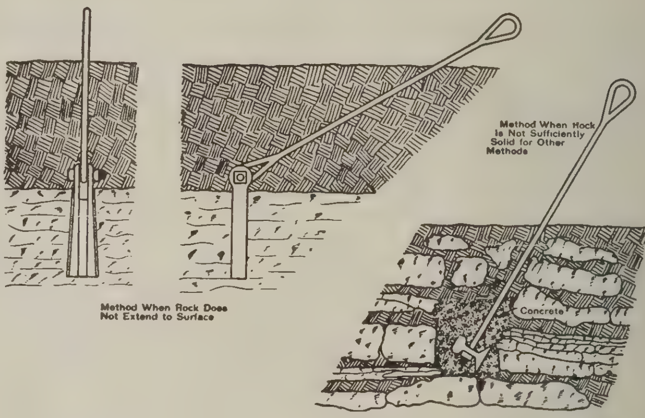
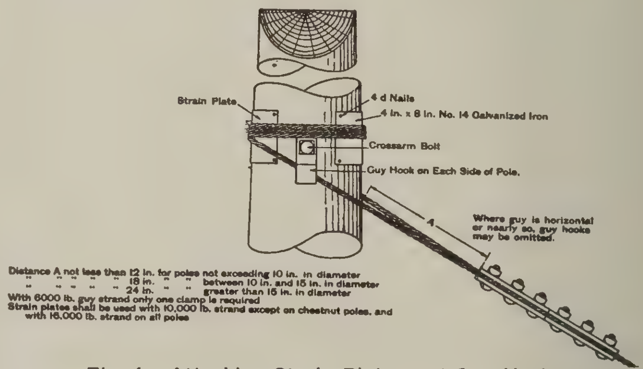
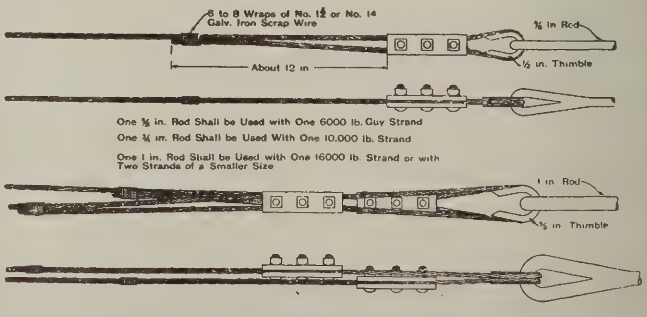

Method When Rock Is Not Sufficiently Solid for Other Methods
Concrete
Method When Rock Does Not Extend to Surface

Fig. 3. Special Method of Anchoring in Rock


Strain Plate
4 d Nails
4 in. x 8 in. No. 14 Galvanized Iron
Crossarm Bolt
Guy Hook on Each Side of Pole.
A
Where guy is horizontal or nearly so, guy hooks may be omitted.

Distance A not less than 12 in. for poles not exceeding 10 in. in diameter
" " " " " 18 in. " " between 10 in. and 15 in. in diameter
" " " " " 24 in. " " greater than 15 in. in diameter
With 6000 lb. guy strand only one clamp is required
Strain plates shall be used with 10,000 lb. strand except on chestnut poles, and with 16,000 lb. strand on all poles

Fig. 4. Attaching Strain Plates and Guy Hooks



One ⅝ in. Rod Shall be Used with One 6000 lb. Guy Strand
One ¾ in. Rod Shall be Used With One 10,000 lb. Strand
One 1 in. Rod Shall be Used with One 16000 lb. Strand or with Two Strands of a Smaller Size

Fig. 5. Attaching Guy Strands to Anchor Rods, One and Two Strands

the side of the pole by guy hooks. The lower end of the guy wire should pass through a thimble attached to the eye of the guy and fastened with one or more guy clamps. (See Figs. 4 and 5.)

Guy stubs should be used only to raise the guys to a sufficient height to clear obstacles and tracks or to prevent their obstructing a highway or thoroughfare, as shown in Fig. 6. Guy stubs should be of good sound timber at least 22 in. in circumference at the top, and anchored in the same manner as a pole.

All curves and corners should be thoroughly guyed in the manner shown in Figs. 7 and 8.

All poles having a side strain should be guyed against that strain. (See Figs. 9 and 10.) These diagrams also show location and method of installing strain insulators in guy wire. In exceptional cases where it is impossible to use a side guy, the poles may be braced in the manner shown in Fig. 11. Pole braces should be at least 18 in. in circumference at the top.

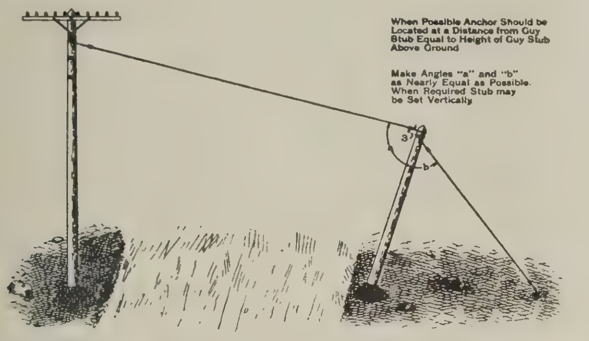

When Possible Anchor Should be Located at a Distance from Guy Stub Equal to Height of Guy Stub Above Ground
Make Angles "a" and "b" as Nearly Equal as Possible. When Required Stub may be Set Vertically
a
b

Fig. 6. Guying Pole to Stub

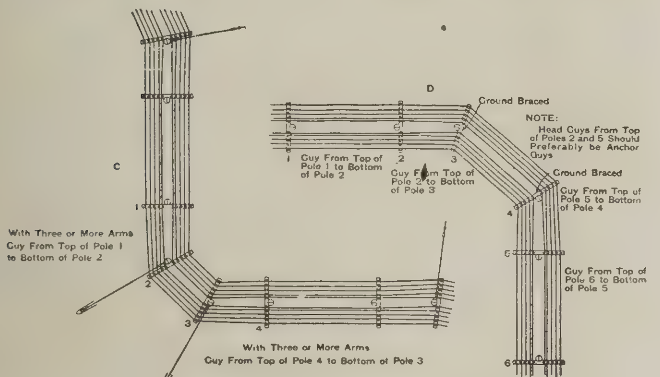

C
D
Ground Braced
NOTE: Head Guys From Top of Poles 2 and 5 Should Preferably be Anchor Guys
1
2
3
Guy From Top of Pole 1 to Bottom of Pole 2
Guy From Top of Pole 2 to Bottom of Pole 3
Ground Braced
Guy From Top of Pole 5 to Bottom of Pole 4
4
5
Guy From Top of Pole 6 to Bottom of Pole 5
6
With Three or More Arms Guy From Top of Pole 1 to Bottom of Pole 2
1
2
3
4
With Three or More Arms Guy From Top of Pole 4 to Bottom of Pole 3

Fig. 7. Guying Right Angle Corners

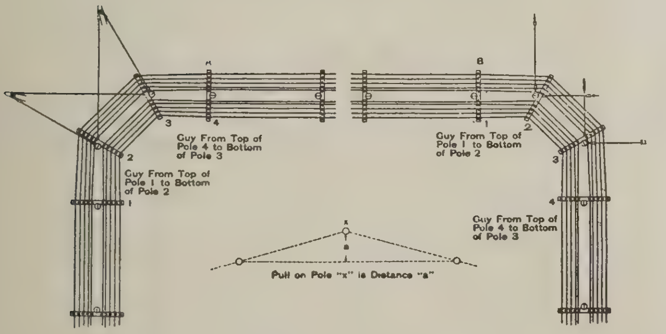

A
B
3
4
2
1
Guy From Top of Pole 4 to Bottom of Pole 3
Guy From Top of Pole 1 to Bottom of Pole 2
1
2
3
4
Guy From Top of Pole 1 to Bottom of Pole 2
Guy From Top of Pole 4 to Bottom of Pole 3
x
a
Pull on Pole "x" is Distance "a"

Fig. 8. Guying Right Angle Corners

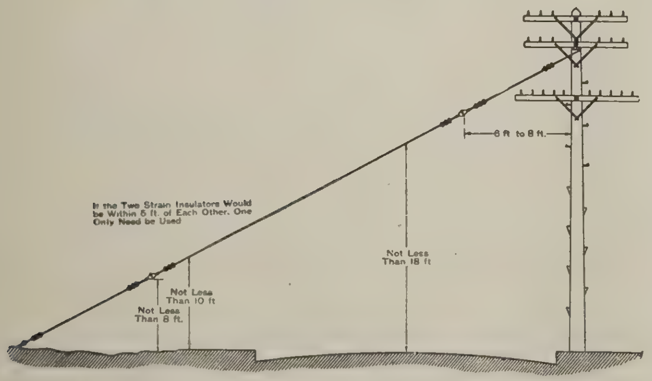

If the Two Strain Insulators Would be Within 5 ft. of Each Other. One Only Need be Used
6 ft to 8 ft.
Not Less Than 18 ft
Not Less Than 10 ft
Not Less Than 8 ft.

Fig. 9. Location of Strain Insulators in Anchor Guys

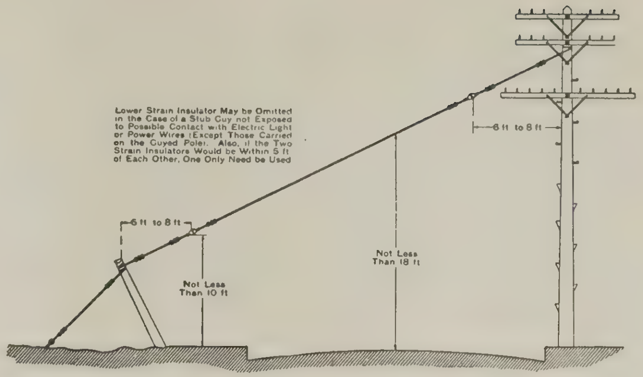

Lower Strain Insulator May be Omitted in the Case of a Stub Guy not Exposed to Possible Contact with Electric Light or Power Wires (Except Those Carried on the Guyed Pole). Also, if the Two Strain Insulators Would be Within 5 ft of Each Other, One Only Need be Used
6 ft to 8 ft
6 ft to 8 ft
Not Less Than 18 ft
Not Less Than 10 ft

Fig. 10. Location of Strain Insulators in Pole or Stub Guys

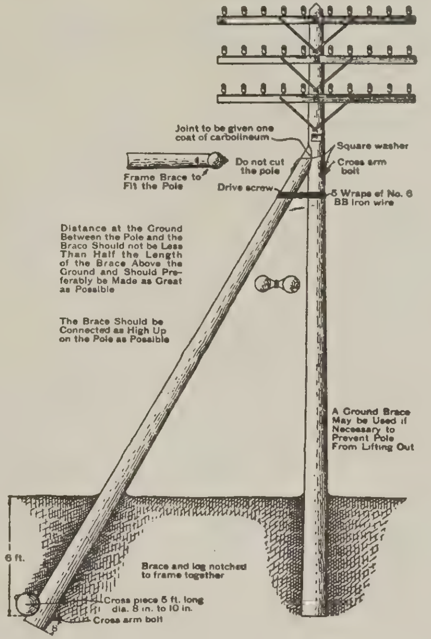

Joint to be given one coat of carbolineum
Square washer
Cross arm bolt
Frame Brace to Fit the Pole
Do not cut the pole
Drive screw
5 Wraps of No. 6 BB Iron wire
Distance at the Ground Between the Pole and the Brace Should not be Less Than Half the Length of the Brace Above the Ground and Should Preferably be Made as Great as Possible
The Brace Should be Connected as High Up on the Pole as Possible
A Ground Brace May be Used if Necessary to Prevent Pole From Lifting Out
6 ft.
Brace and log notched to frame together
Cross piece 5 ft. long dia. 8 in. to 10 in.
Cross arm bolt

Fig. 11. Push and Pull Brace

All terminal poles should be head guyed and side guyed if possible. The head guy that is intended to take the strain of the line should be of greater strength than the combined pull of all the wires upon said line, and if necessary more than one guy should be used to accomplish this result. In addition to this the next adjacent poles should be head guyed to assist in holding this strain.

Guy Wire.

Recommend guy wire to be made of seven strands, double galvanized steel of not less than 5/16 in. diameter.

Galvanized steel wire strand should comply with the requirements of the following table:

Size, Inches	Grade	No. of Strands	Breaking Strength, Lbs.
½	High Strength	7	18,000
	Extra High Strength	7	27,000
7/16	High Strength	7	15,000
	Extra High Strength	7	22,500
⅜	High Strength	7	11,500
	Extra High Strength	7	17,250
5/16	High Strength	7	8,100
	Extra High Strength	7	12,100

Wood.

Because of the low first cost and the fact that the tracks in railroad yards are frequently re-located, the use of wooden poles is recommended. The kind of wood used would depend almost entirely on the selection available in the location where the poles are required.

In order to increase the life of wooden poles, they might be treated with wood preserving fluid by the open-tank or pressure process or by brush treatment at a point extended about 18 in. above and below the ground line, treating the gains and the top of the pole as well. Brush treatment is not very expensive, and would, in all probability, materially increase the life as the poles would be protected at points where decay is most apt to occur.

Another method of protecting the pole butts is to set them in concrete, extending the concrete below the surface of the ground a sufficient distance to give required protection, and above about 8 in.

Chestnut poles should be cut from the best quality, second growth, live white chestnut, cut during the winter months. All poles to conform to the following dimensions:

Length in ft.	Minimum circumference at top in inches	Minimum circumference 6 ft. from butt in inches	Single Crook. Variation allowed in inches	Double Crook, in same plane. Variation allowed in inches	Double Crook Diff. planes inches
30	25	36	8	7	7
35	25	40	10	8	8
40	25	43	12	9	8
45	25	47	13	10	8
50	25	50	14	10	8
55	25	53	14	10	8
60	25	56	15	10	8
65	25	59	16	10	8

Cedar poles should be cut from the best quality arbor vitae or white cedar, live, green wood. All poles to conform to the following dimensions:

30	22	32	8	7	7
35	22	34	10	8	8
40	22	38	12	9	8
45	22	43	13	10	8
50	22	47	14	10	8

Gains should be cut at right angles to the ridge of the pole roof, and should not be more than 1 in. and not less than ½ in. deep and of size to suit crossarm. They should be spaced at least 24 in. between centers and 10 in. from the apex of the pole to the center of the top gain.

In case of a curved pole, the gains should be cut on the concave side, that is, the side which bows inward.

Concrete.

While the cost of concrete poles is high, it may be advisable to use them under special conditions where the track layout can be considered as a permanent installation. These poles will presumably have a very long life, but no actual figures seem to be available. There is a possible chance of failure of the poles due to electrolysis or a spawling of the concrete near the ground line due to absorption of moisture and subsequent freezing. A suggestion to minimize or eliminate this trouble, would be to treat the pole butts with crude oil to prevent absorption of moisture or encasing the pole at the ground line with concrete.

Steel.

The life of these structures would vary depending on local conditions and the care taken to prevent same by painting at proper intervals. The inspection and painting of these structures will be more or less expensive. In general, steel poles should be so designed as to facilitate, as far as practicable, inspection and painting. They should be set in or on concrete and when carrying high tension circuits should be grounded and inspected at sufficiently frequent intervals to assure a proper grounding at all times.

Pole Fittings

Crossarms.

All wooden crossarms should have a cross section of not less than 3¼ x 4¼ in.

Would recommend that crossarms be made of cypress, red pine, white pine, yellow pine, spruce or Douglas fir. All pieces should be straight, close grained, sound, and free from all splits and shakes, and provided with water shed on top.

The holes for pins should be bored clean and true.

There seems to be considerable difference of opinion as to the advisability of treating crossarms, but a brush treatment of some good wood preserver at the point where the arm fits into the gain is in all probability advisable.

Wooden crossarms should be properly fitted in the gains and held in place by through bolts fitted with square washer on each end. The arms should be fitted with iron or steel braces. These should be attached to the crossarms by carriage bolts located at least two inches from pine hole and to the pole by lay screws.

On straight lines crossarms should be placed at right angles to the direction of the line, and arms on adjacent poles should face in opposite direction.

Double crossarms should be used on all terminal poles, corners, track crossings and at all spans in access of 125 ft. The arms to be attached to the poles by through bolts and re-inforced by additional bolts placed 10 in. from each end. These bolts to be threaded on both ends so as to place nuts and washers on the inside and outside of arms.

Spacing of pins: Spacing should be 36 in. centers, sides 12 in., ends 4 in.

Pins—Wood.

Wooden pins should be made of the best quality, sound, clear split Locust; free from knots and sap, and should be boiled in paraffine oil, and should have eight turns of thread per inch, and should not be less than 1½ in. x 9 in. Pins should be fastened to arm with not larger than a 6-d wire nail driven straight into the center of pin.

Pins—Steel.

Where the pin strains are great as where supporting heavy wires or corner construction, a steel truss pin, as shown in Fig. 12, should be used, which seem to be well designed for the purpose in that its base has a large bearing surface on the arm and a ⅝-in. bolt does not weaken the strength of the crossarm materially.

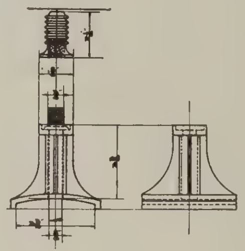


Fig. 12. Steel Truss Pin

Steps.

It is recommended that pole steps be used on all poles supporting lamps and such others as may be required. The lower steps should be placed approximately 2½ ft. from the ground line and the steps should be spaced 36 in. on each side staggered so that the distance from one step to the next does not exceed 18 in. Steps should be so located that they are parallel to the track and carried up the pole in this manner to a height of at least 20 ft. and then so placed so as to give easy access to the cross arms, and additional steps should be added opposite the top step on each side of the pole. (See Figs. 13 and 14.)

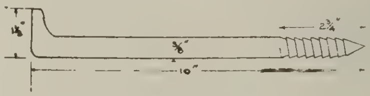


Fig. 13. Pole Step

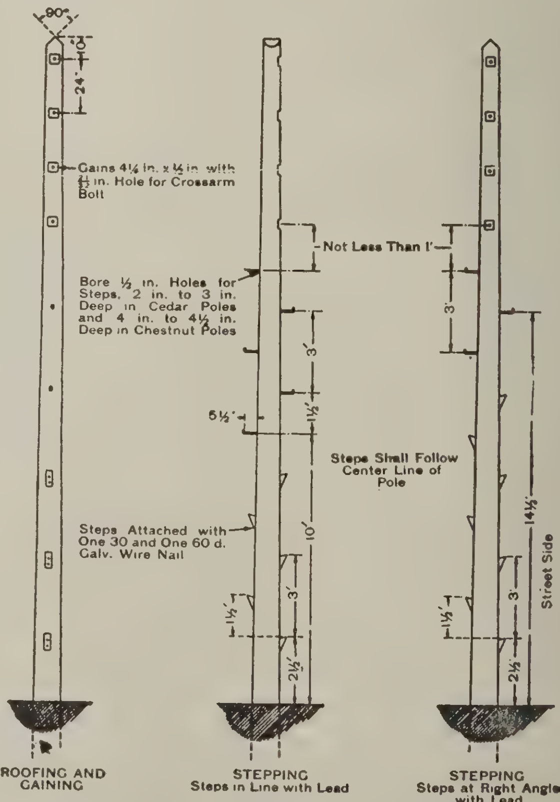
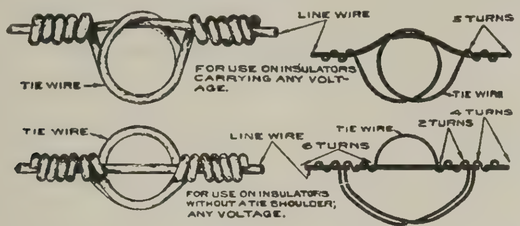

90°
10"
24"
Gains 4¼ in. x ½ in. with 11/16 in. Hole for Crossarm Bolt
Not Less Than 1'
Bore ½ in. Holes for Steps, 2 in. to 3 in. Deep in Cedar Poles and 4 in. to 4½ in. Deep in Chestnut Poles
3'
5½"
1½'
Steps Shall Follow Center Line of Pole
Steps Attached with One 30 and One 60 d. Galv. Wire Nail
10'
14½'
Street Side
3'
1½'
2½'
ROOFING AND GAINING
STEPPING
Steps in Line with Lead
STEPPING
Steps at Right Angles with Lead

Fig. 14. Roofing, Gaining and Stepping Poles

Insulators.

Porcelain (preferably brown) insualtors designed for the proper working voltage and size of the conductor, are recommended, due consideration being given to any unusual conditions such as might occur when the insulators are subjected to an excessive amount of bituminous coal smoke or moisture. When the wires are attached to the side of the insulator, the following method of attaching is recommended, as shown in Fig. 15. The tie is to be annealed wire of the same size and insulation as the line wire up to and including No. 2 B. & S. gage. When the line wire is attached to the top of the insulator, it is recommended that it be attached to the insulator by saddle tie. (See Fig. 16.) When clamping devices are used, a clamp similar to that shown in Fig. 17 is recommended to be used.


LINE WIRE
5 TURNS
FOR USE ON INSULATORS CARRYING ANY VOLTAGE.
TIE WIRE
TIE WIRE
4 TURNS
2 TURNS
TIE WIRE
LINE WIRE
TIE WIRE
6 TURNS
FOR USE ON INSULATORS WITHOUT A TIE SHOULDER; ANY VOLTAGE.

Figs. 15 and 16. Ties for Top and Side Groove Pin Type Insulators

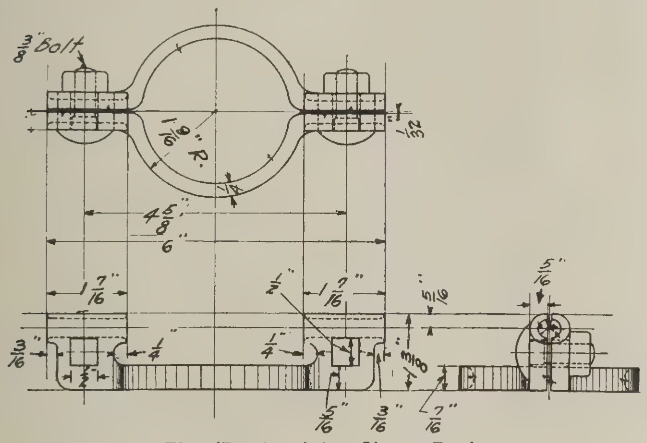


Fig. 17. Insulator Clamp Device

Hardware.

Through bolts should be not less than 5/8-in. diameter with square head and of suitable length to allow washers on each end and a full nut on thread end after bolt is in place.

Washers for through bolts should be not less than 2¼ in. x 2¼ in. x 3/16 in. bolt. (See Figs. 18 and 19.)

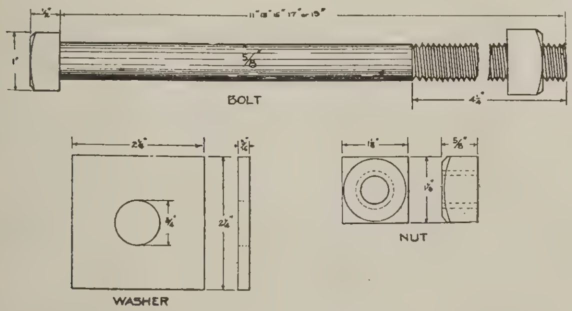


Fig. 18. Cross Arm Bolt

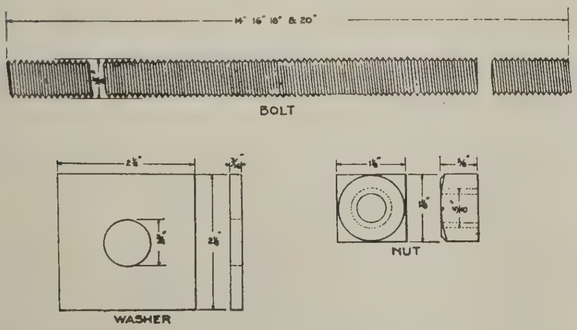


Fig. 19. Rods for Double Cross-arm

Braces should be made of iron or steel of not less than 1¼ in. x ¼ in. and of a length suitable to properly support the arm to which they are attached. (See Fig. 20.)

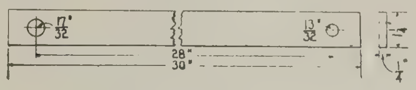


Fig. 20. Cross Arm Brace

Carriage bolts for fastening braces to arms should be of button head type, ⅜ in. diameter, of proper length to allow full thread for end after passing through braces. (See Fig. 21.)

Lag screws for fastening braces to poles should not be less than ½ in. x 3½ in. (See Fig. 22.)

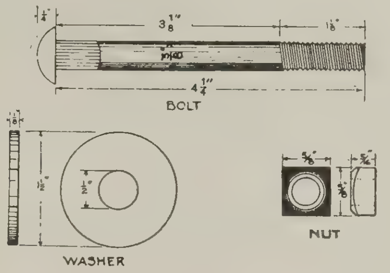


Fig. 21. Standard Carriage Bolt

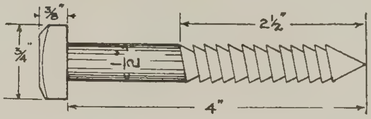


Fig. 22. 4-Inch Fetter Drive Screw

Pole steps should not be less than ⅝ in. x 10 in., and driven not less than 4½ in. in pole. (See Fig. 13.)

Guy clamps to be made of two pieces of malleable iron or rolled steel properly grooved for size of wire used, and fastened together with three bolts of not less than ½ in. diameter. (See Fig. 23 and 24.)

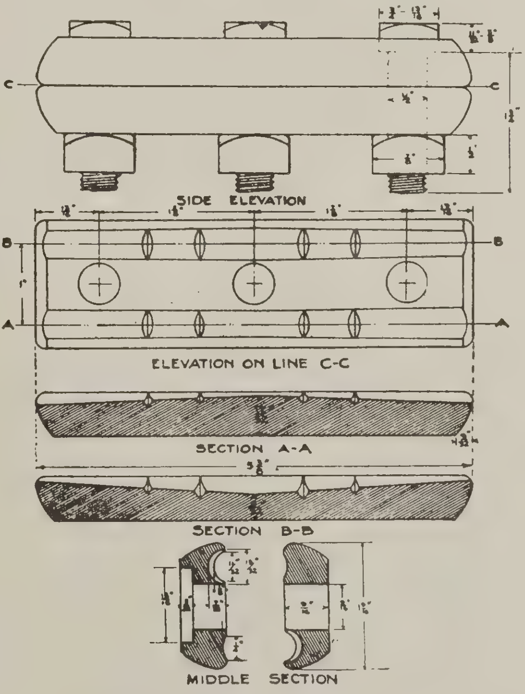


Fig. 23. Malleable Iron Guy Clamp

Guy rods should be of steel not less than ¾ in. diameter with welded eye on one end and with suitable thread, nut and washer on opposite end, and of sufficient length to project 12 in. above ground. (See Fig. 25.)

Thimbles should be used wherever guy wire is fastened to guy rod or eye bolt and of suitable size for guy wire and should be made of iron or steel of the following weights:

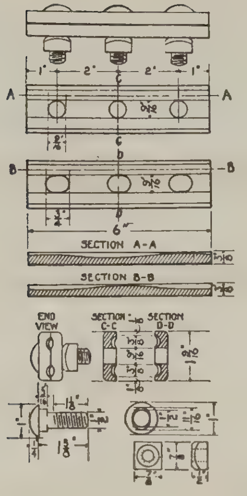


Fig. 24. Rolled Steel Guy Clamp

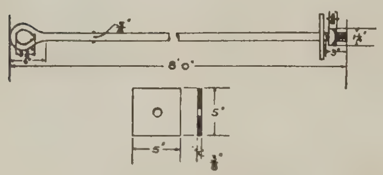


Fig. 25. Guy Rod

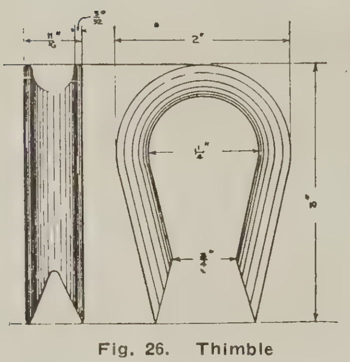


Fig. 26. Thimble

Less than ½ in., 20 lbs. per 100
½ in. to 1 in., 32 lbs. per 100

(See Fig. 26.)

All of the above hardware is recommended to be of the hot dip process of galvanizing.

Distribution

Overhead Systems.

It is desirable to eliminate as much as possible overhead high tension distributing circuits, and for this reason it is recommended, where practicable, that electricity be supplied from one secondary distributing system. In a long narrow yard or very large yard of other shape, it may not be practicable to take care of requirements in this manner, but in this event two or more secondary distributing systems might be used, each receiving its power from one or more transformers.

This general recommendation will apply to both lighting and power, except when the power units or local lighting load were of such capacity as to make the same impracticable, in which case separate transformers could be used. It is recommended that with overhead construction, transformers be placed on poles, and that they be attached to an independent crossarm or fixture located below the lowest crossarm carrying wires. A high tension disconnecting device located at transformer poles should be attached to the high voltage crossarm so as to disconnect any high tension lines leading down the pole to the transformer. When required, a two-pole structure may be used to support large transformers.

Distributing circuits should be properly protected by lightning arresters, or a ground wire run on top of pole line, or possibly a combination of both, with due consideration given the use of choke coils.

Arresters.

Arresters should be located in readily accessible places away from combustible materials and as near as practicable to the point where wires enter the building. In all cases, kinks, coils and sharp bends in the wires between arresters and outdoor lines should be avoided as far as possible. They should be connected with a thoroughly good and permanent ground connection by metallic strips, or wires having a conductivity not less than that of a No. 6 B. & S. gage copper wire, which should be run as nearly in a straight line as possible from the arresters to the ground connection. Ground wires for lightning arresters should not be attached to gas pipes within the buildings nor be run inside of iron pipes.

All choke coils or other attachments, inherent to the lightning protection equipment, should have an insulation from the ground or other conductors equal at least to the insulation demanded at other points of the circuit.

Generally speaking, arresters should be spaced one-half to three-quarters of a mile apart to give proper protection and at all points where overhead lines connect to underground.

Secondary Lines.

When carried by the same poles, all secondary lines should be located below the high tension lines. Where a secondary circuit enters a building, a fuse and switch should be placed inside of building as close as practicable to the entrance—the fuse so located so as to protect the switch. This is done so that in case blades on switch were short circuited, the fuse would protect the short circuit. The incoming wires should be attached to the insulators and supported by substantial metal brackets in such a manner as to avoid the possibility of moisture from the roof, grounding or short circuiting the lines. (See Fig. 27.)

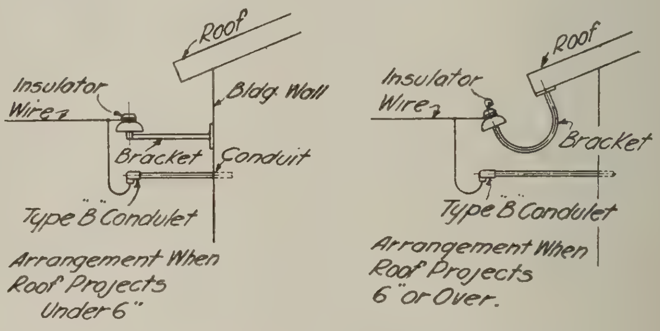


Fig. 27. Attaching Wires to Bracket Insulators

Line Wires.

Recommend No. 4 B. & S. gage, medium hard drawn, copper wire as a minimum size line wire, and that all line wires be stranded.

Outside Construction--Underground

General.

We believe it desirable to install complete underground conduit system in yards in preference to overhead construction for the following reasons:

Greater assurance of continuity of service, elimination of accidents to pedestrians from broken wires, damage by storm or a general interruption of service on account of an individual pole having been broken down by derailment.

When this type of construction is once properly installed, the cost of up-keep should be very low. Further, any changes in the track layout does not interfere to the same extent as with overhead construction.

Conduit.

For trunk lines, would recommend the use of fibre conduit having 3½ in. bore and a wall of not less than ¼ in. thickness. Conduit to be protected by concrete, the trickness of which will be governed by local conditions. Under ordinary condition would suggest 1 in. of concrete between the ducts with a 3 in. wall around the outside of ducts, the top of ducts to be at least 2 ft. below the surface of the ground.

For single duct branch lines, would recommend fibre of proper size having a bell or screwed joint; walls to be not less than ⅜ in. thick. Duct to be laid in the ground without concrete protection; top of duct to be protected by 1½ in. boards at least 2 in. wider than the outside diameter of duct; top of duct to be at least 2 ft. below the surface of the ground.

Manholes.

In general, the distance between manholes should not exceed 500 ft. Trunk line manholes should have an oval inside section with a minimum clear height of 5 ft., inside length of 6 ft., and 4 ft. 6 in. wide at the widest point. The casting at the top of manholes should be designed for two covers of not less than 24 in. diameter; the inside cover to be arranged for use with gasket if desired. (See Fig. 28.) It is very desirable, but not essential, in all cases, to drain manholes. (Expense of drain connections in some cases, is prohibitive.) When used, would suggest locating drain piles in one corner of the manhole floor, for if placed in center, they are apt to become blocked. Where the soil is of a sandy or gravel nature, a blind drain would be sufficient.

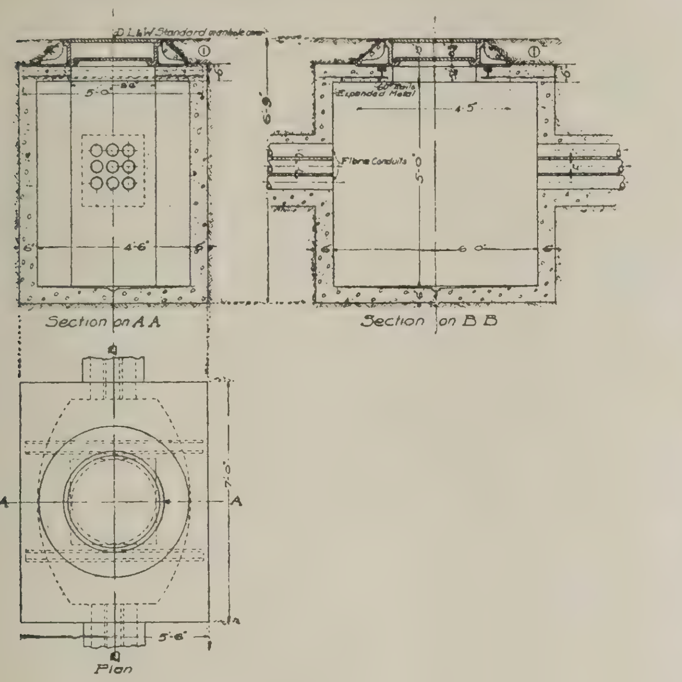


Fig. 28. Sections of Man Holes

Branch Lines.

Should be provided with pull in boxes to meet local conditions. (See Fig. 29.)

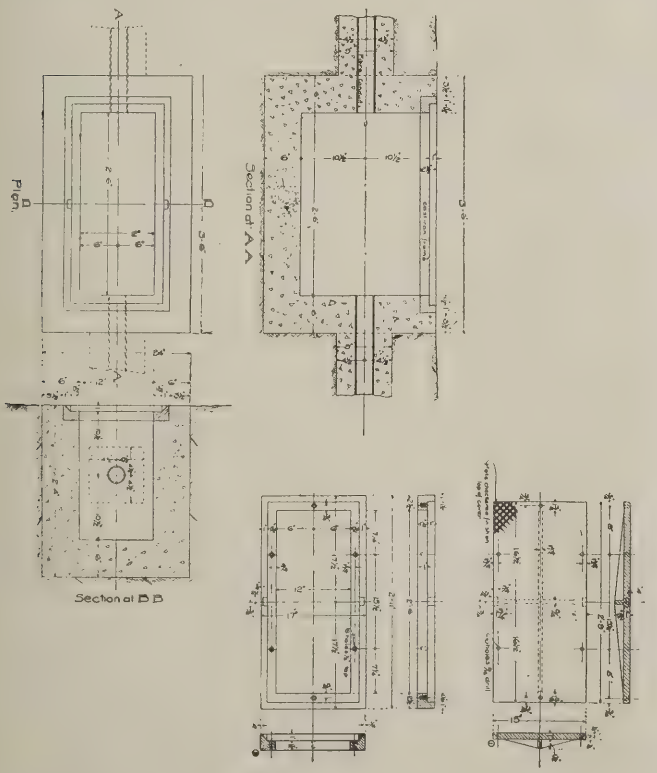


Fig. 29. Plan and Section of Manhole and Lamppost Hole

Cables.

For both low and high voltage underground work, would suggest the use of lead sheathed copper cables in all cases.

For alternating and direct current would recommend that two or more wires of the same circuit be enclosed in the same

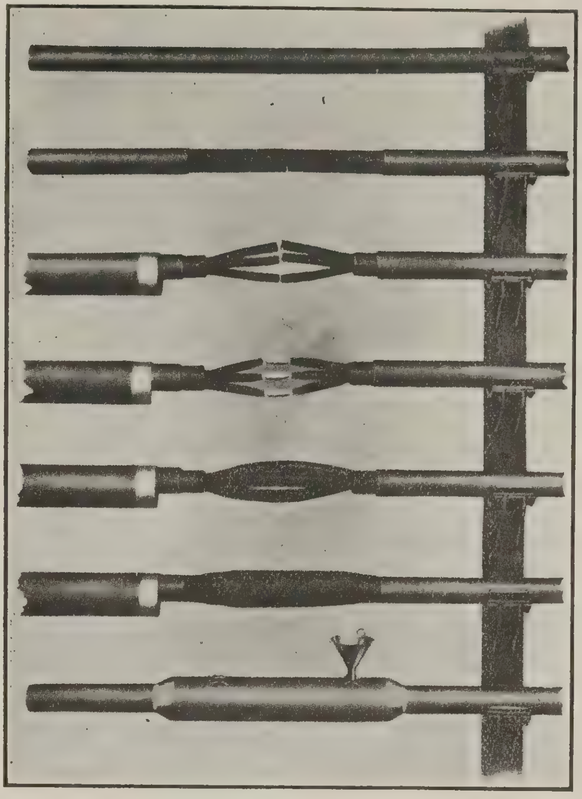
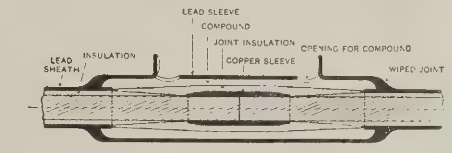
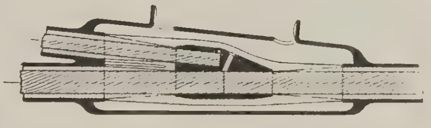


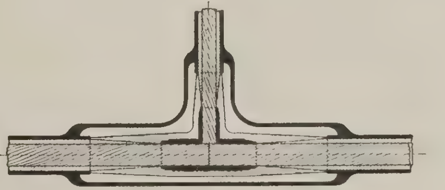
Fig. 32. Showing the Various Steps in the Making of a Three-Conductor Paper Insulated Lead-Covered Cable Joint



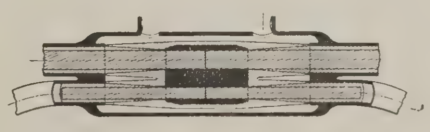
Straight-way Single Conductor Cable Joint



Single Conductor Y-shape Branch Joint

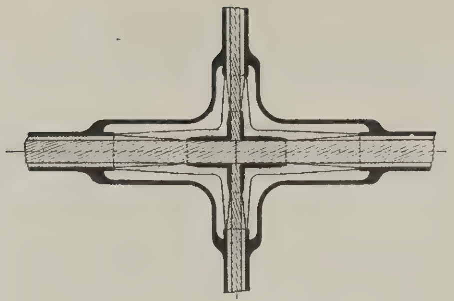


Single Conductor Right Angle Branch Joint

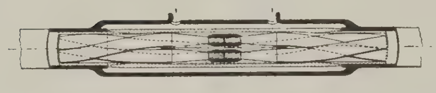


Two Parallel Conductor Branch Joint

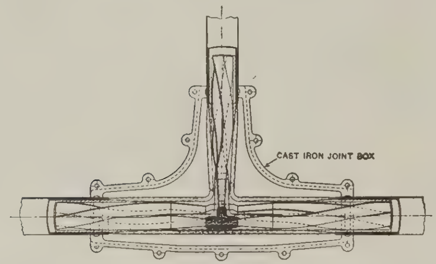
Fig. 30



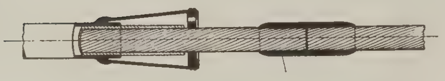
Two Right Angle Conductor Branch Joint



Straight-way Three-conductor Cable Joint



Three-conductor Right Angle Branch Joint



Insulated Single Conductor Cable Connection to a Bare Cable

Fig. 31

sheath. Insulating material to be of rubber, varnished cambric or paper. The selection of the different types of insulation would depend upon the voltage and service for which the cable is to be used.

Under Figs. 30, 31 and 32, we have shown the method of making joints of lead sheath cables.

Would recommend the use of single conductor cables for high tension series work and for low tension work where the size of each conductor exceeds No. 0 B. & S. gauge. The reason for recommending single conductor cable for low voltage work would be where there are three wire mains, and single conductors make a more flexible and easier method of taping onto for branch circuit than with a three conductor cable.

Distribution—High Voltage.

Place one or more banks of transformers at centers of distribution as may be necessary, locating transformers on poles or in fireproof vaults located in some convenient building. High tension cables to transformers should terminate in porcelain disconnecting pot-heads. Would suggest the use of primary fuses on all transformers except when one bank of transformers is fed from a separate circuit which has its own protection.

Distribution—Low Voltage.

The secondary of the transformers to be taken to a distributing panel located in a building as close to the transformers as is practicable. The secondary feeders to run from this point underground to the various buildings. Where taps are made at secondary underground mains, no fuse protection is to be used. (Cables to be fused where they enter building.)

Distribution—Series Circuits.

For series circuits recommend using single conductor lead sheathed cable in duct as described, taking advantage of trunk line ducts where possible. For convenience of installation and inspection, a small concrete pull box should be placed near the base of each lamp. (See Fig. 29.)

In order to protect lamp trimmer it is recommended that all series arc lamps be provided with absolute cut-outs of the type in which the lamp leads are detached from the cut-out and visible when the circuit is open.

Recommend either solid or bored wooden poles for supporting the lamps. The underground wires should be carried up the pole through the opening in the bored poles or in iron pile attached to the side of solid poles; the bored type of pole is preferred for heights not exceeding 30 ft.

Yard Lighting

Recommend liberal lighting at switches and general illumination for the entire yard. When new yards are being considered, due consideration should be given to the question of illumination and the track layout, such as to provide space for the necessary poles and to permit of proper track clearance.

Railroad yards usually cover such a large area, that a series lighting system is best adapted to meet the requirements.

Comparison of Various Types of Units.

There are three types of series lamps offering the greatest advantages, which are: carbon flame, metallic flame, and series tungsten.

Carbon Flame—Some of the advantages are: where conditions are very severe on account of smoke, the yellow carbon flame lamp seems to be best adapted because of the intensity and penetrating qualities of the yellow ray; and it can be used with a. c. or d. c. electricity.

Carbon Flame—Some of the disadvantages are: its high cost of maintenance; and that its light distribution could be improved if its candle power curve were more nearly approximated to that given by lamp of the metallic flame type; also the slaging of carbons.

Metallic Flame—Some of the advantages are: long life of electrodes; flat distribution curve; freedom from the slag characteristics of the carbon flame lamp; lower cost of maintenance as compared with carbon flame; also suitable for lighting large area on account of its high candle power and flat distribution curve. One of its disadvantages is that it is restricted to direct current.

Tungsten Lamps—Some of the advantages are: it is the most flexible of the types mentioned, and can be used on any series circuit and various candle power lamps can be used on series circuit. When necessary to light large area, a number of units can be placed on one pole. The size or number of units can be selected as desired.

Spacing and Height.

Carbon Flame—For a lamp designed for not less than 7½ amperes, we recommend a spacing for general yard lighting not to exceed 375 ft. For switch lighting, 250 ft. or less if required. The height of this type should be not less than 32 ft. above rail, preferably more, say, 42 ft.

Metallic Flame—For a metallic flame designed for not less than 6.6 amp., we recommend the same spacing and height as recommended above.

Tungsten—For a tungsten unit of 600 c. p. size, recommend a spacing of 125 ft. for general illumination and closer spacing for special location, such as switch points. Height 20 to 25 ft. above rail.

Committee on Reciprocal Relations

The committee on reciprocal relations had no questions arising during the past year requiring its service and it is recommended that the committee be continued with the same personnel for next year.

(Signed) Jos. A. Andreucetti,
J. R. Sloan,
L. S. Billau, Chairman.

Committee on Wire Crossing Specifications

Your committee appointed to consider wire crossings specifications made a report at the June convention at Atlantic City, at which time they advised that they had received an invitation to take part in the meeting which was to be called by the several associations which had joined in making the wire crossings specification that had been adopted by the Association of Telegraph Superintendents, but so far this meeting, to the best of our knowledge, has not been held.

As this committee, as has been pointed out previously, can only work through the Association of Telegraph Superintendents, we could take no further action.

We would suggest that the committee be continued for the coming year with the same personnel.

Respectfully submitted,
J. R. Sloan, Penn. R. R.,
Chairman.

Committee on Standard Rules for Car Wiring

General.

These specifications are intended to cover the complete installation of an electrical wiring system for the lighting of passenger cars that will meet with the requirements of the Board Of Fire Underwriters Rules.

The wiring system shall be complete, including conduits, conduit fittings, outlet boxes, switches, cutouts, fuses, sockets, fixtures, wires, cables, etc. The dynamo, regulators and the batteries shall be installed under their respective headings.

The wiring shall be arranged for use in connection with an axle driven———volt generator, operated in conjunction with a storage battery, mounted under the car body. A car lighting system is to be used. Wiring must be in accordance with the Railroad Company print. A floor plan showing location of lights shall accompany specification of each class of car.

It shall be understood and agreed that these specifications shall be fulfilled in their true spirit and meaning, to the satisfaction of the ——————— Department of the Railroad Company. And they shall also be considered as providing for a first-class and complete system of wiring in every respect, and it shall be further understood and agreed that any apparatus or appliance essential to the proper and convenient operation of the system shall be supplied and installed at cost, even though such appliance be not called for in these specifications. All special equipment shall be listed separately.

The car builder shall furnish blue prints of the details and application as he interprets the lighting arrangement and submit them to the Railroad Company for approval before starting work. Builders must in all cases advise themselves that the specifications in their possession are of the latest revision.

Conduit.

All wiring must be done in approved hot galvanized steel conduit of sufficient size to allow for the pulling in freely of all wires after conduit is in place, and be so arranged that wires can be renewed without necessitating the removal of the interior finish of car. All conduits must be securely fastened by pipe strap or their equivalent not more than 5 ft. apart where possible ends must be cut square and reamed smooth; ends must be butted together in couplings; lock nuts and bushing must be used in junction boxes and outlets where other fittings are not specified. No conduit smaller than ½ in. shall be used, except in partitions where ⅜ in. conduit may be used where specified. Where pipe threads are exposed they shall be leaded and painted. All conduit for circuit wiring shall be run inside under the car finish unless otherwise specified.

Train line conduit may be run on the roof of the car where conditions are such that prevent the placing of this conduit inside the car. The 1¼ in. conduit for generator leads shall run direct from the generator terminal block to the regulator locker. The conduit for battery leads shall be not less than 1 in. and shall run direct from the battery box to the switch board locker with a junction box where battery charging plugs are tapped on the battery leads.

All conduit under car shall be securely fastened to prevent movement, junction boxes and terminal fittings shall be secured by bracket or other fastening independent of the conduit. A junction box shall be placed in the conduit where a reverse or double bend occurs or where the run is too long to allow for wire to be readily fished through the conduit. One piece conduit fitting with threaded hubs should be used in place of boxes where a lock nut and bushing is used on account of same becoming loose in service. All junction boxes used under car should be of a rust resisting type with removable side plates so as to permit the renewal of sections of conduit without necessitating stripping of all conduit under car. A substantial cast iron weatherproof fuse box with hinge cover and substantial wing nut catch shall be installed at each end of battery box. Each fuse box shall contain a new code single pole fuse block of a capacity suitable to the needs of the car.

The conduit system should be constructed so as to form one perfect electrical conductor and this shall be connected to the ground by a suitable ground clamp connection to the metal frame of the car, or if the conduit system consist of several separate sections, the sections should be bonded to each other and the system grounded, or each section may be separately grounded as required above. Connections from conduit to ground should be exposed to view and readily accessible and should be made with standard ground clamps to which a ground wire of at least No. 6 B. & S. gauge should be soldered. Light fixtures and fans should either be thoroughly insulated from or else solidly connected to the metal of the conduit system. The car builder shall furnish complete conduit plan to the Railway Company for approval.

Wires.

All wires and cables shall be insulated with———insulation, double braided, unless otherwise specified. No wire smaller than No. 14 B. & S. gauge shall be used unless otherwise specified; main circuit wires must be No. 10 B. & S. unless otherwise specified. All wires of No. 8 B. & S. gauge and larger must be stranded. Generator leads and train connector cable shall be extra flexible as prescribed. Slack wires are to be left at conduit, fixture and bracket openings where possible, and wires are not to be drawn in tight in conduit or places where slack wires may be placed. No joints or splices will be permitted in the conduit between junction boxes or fittings. All joints are to be of the Telegraph or Western Union type unless otherwise specified. The soldering paste or flux must be free from acid detrimental to the wire, free acid not being permitted. The insulation must be removed without marking or cutting the wire. The exposed surface of the joint shall be thoroughly sweated and tinned, so that solder completely covers all exposed parts of the wire so as to prevent corrosion. Care must be taken that no sharp point of wire or solder is left to peirce insulation and cause a ground. The joint shall be covered with————splicing tape of sufficient thickness to make the joint equal in insulation to rest of wire; this shall then be covered with————tape, same to be painted where exposed to the weather.

The generator leads from the dynamo to terminal block on the car body shall consist of two No. 4 B. & S. extra flexible stranded (133 strand) conductors with 4/64 in. wall covered with one linen braid saturated with weatherproof compound. The field leads shall be No. 6 extra flexible stranded (61 strands) conductor, with 4/64 in. wall covered with one linen braid saturated with weatherproof compound. The large size of field leads is to insure mechanical strength. Field leads from receptacle to switch board shall be No. 10 solid wire. The connector cable shall be No. 2 B. & S. extra flexible stranded (133 strands) cable with 4/64 in. wall and covered with linen braid saturated, or No. 2/0 B. & S. flexible stranded (836 strands) with 5/16 in. wall covered with single linen braid saturated with weatherproof compound. Battery connector cable shall be No. 4 B. & S. gauge stranded copper (133 strands) insulated with 4/64 in. wall————insulation, plain, with (no tape or braid).

Switchboards.

The switchboard panel shall be equipped with 3-100 ampere double pole, single throw knife switches mounted in a vertical position at the top of the board. Switches must be provided with wing nuts for open stamped link fuses, with 2⅜ in. centers. The left hand switch must be marked "BATTERY." This switch shall have a hole bored in the blade and upper left hand clip for a 1/16 in. cotter key to prevent the same from being opened by train crews. Battery switch must be cut in solid with copper strips in place of link fuses. The center switch must be marked, "LIGHTS" and the right hand switch, "TRAIN WIRES." Below these switches should be located the fuse cutouts for the lamp circuits.

Each circuit of the car wiring should be provided with an automatic fuse cut-out in each wire and the fuses in the same be so proportioned that they will blow and disconnect the circuit before the wires become overheated. The table of "Allowable Carrying Capacities of Wires" issued by the National Board of Fire Underwriters should guide the installation of these cut-outs. The fuses for lighting and fan circuits should be located on the switch board panel in the car. The fuses protecting the generator should be located on the regulator panel and the fuses protecting the batteries should be located in iron boxes in the conduit system just outside of the battery box. No lamp regulator wires should be connected on the lamp circuit side of the fuses. The two bottom cut-outs on the switch board controlling the fan circuits should be connected direct from the battery circuit independent of the main light switch and lamp voltage regulator. The right hand connection facing equipment should always be positive. The switch board should be of uniform width of regulator panels. Fuse cut-outs, switches and other mountings on switchboard shall be so arranged that any part can be removed or replaced from face of board without taking down the switch board panel.

Regulator Lockers.

The locker shall be metal lined or constructed of steel, not less than 12 in. in depth or 20 in. in width. Where the generator and lamp regulators are mounted in the locker, the height shall be not less than 40 in. above the door opening and where the switch board is placed in the same locker the height shall be not less than 56 in., this height shall be determined by the number of circuits on switch board. The regulator shall be mounted on Z irons which shall be securely fastened to the back of the locker by bolts where the car constructions permits, and where screws are used they shall be spaced not more than 4 in. apart. The switch board and regulator panels shall be secured with ⅜ in. hex-head bolts which shall be slotted for screw driver. The Z iron shall be tapped to take a ⅜ in. standard thread bolt. The locker shall be well ventilated with not less than a 4 in. pipe carried through the roof of the car and equipped with a roof jack. A 2-in. pipe nipple shall extend through the car floor with a bushing on both ends, a piece of copper screen shall be fitted between the ends of the pipe and the bushings. Where the locker is built below the door level, the bottom of the locker shall be closed so that material or rubbish cannot accumulate in it. Where the door extends to the floor a false bottom shall be placed in the locker on an angle of 45 degrees so that rubbish cannot be swept into the locker. Under no circumstances will the mounting of the regulator below the level at door opening be permitted.

Where regulators are mounted on a partition, this must be sufficiently braced to prevent undue vibration, and wherever possible the regulator locker should be built lengthwise of the car instead of across the car as is now the general practice. The locker should be built in two compartments where possible and the switchboard placed in one compartment and the regulating apparatus in the other. A standard coach lock must be placed on the regulator locker and a spring catch on the switch board locker doors. Wiring diagram and equipment card must be framed in the regulator locker, and instruction card must be framed in the switchboard locker. A locker light, controlled by a ——— 2322 door switch, shall be placed in each compartment where lockers are constructed in two compartments, one above the other. The switchboard shall be located in the upper locker.

A——— 2309 locker hook, to hang up the train connector cable shall be placed in each locker. A slide or card clip shall be placed in the locker for report blanks. A 60 volt green G-18½ pilot light shall be placed outside and over the door of the locker or where it can be readily seen by the car crew.

Where the locker is built at the end of the car, the back of the locker must be securely fastened to the car end to prevent same tearing loose when car is struck a severe blow as often occurs in switching and results in regulator panels being thrown forward and tearing loose from their fastening if not properly secured.

Fixtures.

The fixtures should be designed so as to be easily wired, all sharp corners runded off so as to prevent the cutting through of the insulation of the wires. A high grade heat resisting insulation should be used on all fixture wires. Nothing less than a standard ⅜ in. socket base with standard pipe thread and center spring contact shall be used. All fixtures of any certain design shall have a standard base, with holes bored to a template, so that when a fixture is removed another of the same design can be put up in its place without necessitating the boring of new screw holes. Where fixtures are fastened to the car roof with bolts passing through roof with cone cap covering same, a brass cast nut with extension shank reaching to the face of the interior finish of the head lining of car, shall be provided, so that the fixture can be removed from the inside of car without disturbing the cones on roof.

Porcelain sockets set in a low melting composition should not be used and the use of fine thread small machine screws should be discouraged in the design of car fixtures. The fixtures should be designed so that the glassware can be readily removed and replaced with a minimum amount of labor, when it is taken down to be cleaned. Owing to the severity of vibration in this service the fixtures should be of rugged construction. If combination gas and electric light is used, separate fixtures should be provided if possible, or consistent with the design of the car, having in view the decorative effect and proper distribution of light. An interior finish plan should be submitted for the purpose of locating the fixtures.

Generator and Suspension.

The generator shall be suspended from the end of truck on parallel links as per print furnished by the Railway Company and shall have a clearance above the rail of not less than 6 in. There shall be a clearance of not less than 5 in. between the top of the generator and the car body. The loop formed by the generator leads shall be not less than 8 in. above the rail. A receptacle and plug shall be provided to connect the generator leads to the wiring on the car body that will not necessitate the use of tools to make or break the connection and shall be so designed that the polarity cannot be changed when plug is inserted. The belt shall pass under the brake beam where the truck and car construction permits, and shall clear the brake beam at least ½ in. Where the belt is carried over the brake beam, a clearance of at least 2 in. shall be provided, with brakes set. Where release springs are placed outside of the truck they must be designed so as to permit the removal of the generator and housing and the generator pulleys without interference and must clear each end of generator at least 1 in. to allow for alignment and shifting of the generator. The suspension parts must be securely bolted or riveted in such a manner that there can be no movement of these parts and they must be sufficiently braced to render them secure and safe.

The generator must be easily accessible for an electrical inspector. No apparatus equipment or battery box shall be placed within 5 ft. of the end of the suspension that would interfere with the inspector getting out from under the car quickly in case of necessity. The generator should be placed on the end of the car opposite to the steam drips, etc.; if they are near the generator, they must be provided with a shield that shall come to within 6 in. of rail so that water or waste will be carried past the generating apparatus. Where the lamp regulator is placed under the car body, it shall be located in a convenient and accessible place so that it will not interfere with the cleaning of air cylinders or interfere with other apparatus. The car builders shall furnish an under-body print showing location of all apparatus placed under car body, with clearance shown in detail. All equipment must conform to the clearance adopted by the American Ry. Ass.'s diagram covering standard limit of clearance lines for third rail and rolling equipment. (See circular No. 1192).

Battery Boxes.

Wooden battery boxes are recommended but where steel boxes are specified they should be as follows: They must be made of ⅛ in. steel, divided into two compartments, each having inside dimensions as follows: 22 in. high, 28 in. deep, 45 in. long. Each compartment must be lined with wood, ¾ in. thick on top, sides back and doors. The wooden bottom must be 1 in. thick and so arranged that it can be renewed without disturbing the rest of the wood lining. The wood must be saturated with a composition of one part parriffine and one part beeswax or rosin, and the wood lining must be put in so as to be easily removed. Each compartment must be ventilated with two 1 in. pipe nipples placed in the back of each compartment 2 in. from the top of the battery box. A pressed steel ventilated plate and handle shall be placed on each door. The handle must be of the waterproof type to prevent water being forced into the box when the car is washed.

The doors must be independent of each other and one shall not interfere with the opening of the other. The hinges must be of the extra heavy strap type extending across door to brace it sufficient to carry the weight of the batteries. The door fastener shall be securely mounted and heavy enough to support the entire weight of the battery in the compartment if the battery were accidentally thrown against it due to side motion of car. A brace of 1 in. by ⅜ in. angle or T iron shall be placed inside of the door in front of the batteries extending across each compartment so as to prevent any movement of the battery trays or their loss in case the doors are left open. At least one fastener on each door shall be so arranged that it can be locked or sealed with a car seal if desired.

No obstruction shall be placed in front of battery box doors that would prevent them from being opened or necessitate the use of other than the hinge type of door. The battery box should preferably be placed in the center and 6 in. back from side of car. Conduit entering the box for battery leads, shall not be less than ¾ in. The supports for the battery box shall be independent of it, securely fastened and braced to car body. The supports must pass under the box so as to carry the entire weight of the batteries and be so arranged that the battery box can be removed without necessitating the removal of the supports. The box should be as near dust proof and water tight as it is possible to make it. No fastenings or part of the battery box shall extend to or beyond side finish of car. All clearance should conform to the requirements of the electric zone of New York City.

Charging Receptacles.

The receptacle should be designed so that the strain of the plug is taken on the frame of the receptacle and not on the contact parts of either plug or receptacle; its contact parts should be self aligning. Where mounted under the car they must be placed back 6 in. from the side of the car so that the danger of their being struck and knocked off by baggage trucks and other obstructions on station platforms and in the yards would be reduced to a minimum. A respectacle should be placed on each side of the car so that it can be charged from either side without having to run the charging cable under the car, which practice results in a great many cables being run over and also results in damage to the charging plant and a great deal of expense in renewal of cable.

Fans.

The fans should be so constructed that they can be readily inspected, cleaned, oiled, etc., without taking them down. They should also be so designed that they can readily be removed or replaced; the fan proper being so designed that it can be removed from the base without disconnecting any wires. The fan armature should be provided with not less than a ⅜ in. removable shaft. It should be designed so that it can be easily taken apart and assembled. Where ceiling fans are used, they should be so hung that they can be inspected, oiled and maintained from the inside of car and it should not be necessary to go on the roof of the car to either remove or apply the fan after its original application. Car fans should be equipped with ball bearings and the manufacturers should adopt a standard bearing for all types of car fans.

S. W. Everett, Chairman A. T. & S. F. Ry.
B. Packahy, Rock Island Lines.
J. L. Ohmans, Chicago & Western Indiana R. R.
Geo. B. Colegrove, Ill. Cent. Ry.
F. J. Hill, Michigan Central R. R.

Committee on Wire Specifications

TABLE OF CONTENTS.

PART I.

General.

Scope of report, statement about potential tests and co-operation with American Electric Railway Association.

PART II.

Order Forms.

Instructions for using order forms, the preparation of standard order forms, etc.

Order Form. No.	Title.
I	Bare or weatherproof aerial wire or cable.
II	Bare conductors not for aerial service.
III	Single conductor insulated wire or cable for indoor service.
IV	Single conductor insulated wire or cable for exposed service.
V	Single conductor insulated wire or cable for underground conduit service.
VI	Single conductor submarine or other armored cable.
VII	Single conductor wires or cable for train lighting.
VIII	Multiple conductor cable.

PART III.

General Specifications.

1. General clauses.
   - (a) Workmanship and materials.
   - (b) Inspection.
   - (c) Notification.
   - (d) Tests.
   - (e) Definition of cable size.
   - (f) Thickness of insulation.
   - (g) Stranding.
   - (h) Repairs and joints of insulation.
2. Electrical tests.
   - (a) High potential test.
   - (b) Insulation resistance.
3. Copper, soft, semi-hard and hard-drawn.
4. Tinning.
5. Separator.
6. Grade "A" rubber compound.
   - (a) Composition.
   - (b) Results of analysis.
   - (c) Concentric application.
   - (d) Tensile strength and elongation.
   - (e) Electrical tests.
7. Varnished cloth insulation.
   - (a) Description.
   - (b) Filler.
   - (c) Assembly.
   - (d) Tape.
   - (e) Electrical tests.
   - (f) Temperature coefficient.
8. Impregnated paper insulation.
   - (a) Description.
   - (b) Paper.
   - (c) Compound.
   - (d) Electrical tests.
9. Braids.
   - (a) Description.
   - (b) Tests.
10. Rubber-filled cloth tape.
11. Sheath.
    - (a) Thickness.
    - (b) Composition.
12. Wire armor.
    - (a) Armor.
    - (b) Size of armor wire.
    - (c) Lay.
    - (d) Finish.
    - (e) Direction of lay.
    - (f) Definition of lay.
    - (g) Armor wire.
    - (h) Tensile strength test.
    - (i) Galvanizing test.
    - (j) Flexibility test.
13. Steel tape armor.
    - (a) Description.
    - (b) Armor tape.
14. Cable reels.
    - (a) General.
    - (b) Bushings.
    - (c) Covering.
    - (d) Lagging.
    - (e) Chocking.

PART IV.

Terminology.

1. Wire.
2. Conductor.
3. Stranded conductor.
4. Cable.
5. Strand.
6. Stranded wire.
7. Cord.
8. Concentric strand.
9. Concentric lay cable.
10. Concentric rope lay cable.
11. N-conductor, or multiple conductor cable.
12. N-conductor concentric cable.
13. Duplex cable.
14. Twin cable.
15. Duplex wire.
16. Twin wire.
17. Triplex cable.

LIST OF TABLES.

I. Thickness of insulation recommended by the National Board of Fire Underwriters.
II. Standard stranding.
III. Extra-flexible stranding.
IV. Test potentials, kilovolts.
V. Test potentials, kilovolts.
VI. Megohm-miles at 60 deg. cent.
VII. Mechanical tests of rubber.
VIII. Temperature co-efficients of rubber.
IX. Temperature co-efficient of varnished cloth.
X. Thickness of cotton braid.
XI. Width of tape.
XII. Thickness of lead sheath.
XIII. Armor wire and jute bedding for armored cables.
XIV. Steel tape and jute bedding for armored cables.

Part I--General

The Committee on Wire and Cable Specifications has devoted itself to improving the 1913 Specifications to make them conform with the latest engineering practice, especially the 1914 Standardization Rules of the American Institute of Electrical Engineers.

The Committee recognizes that various grades of rubber insulation may be used with advantage under different conditions, according to the degree of permanence desired, but where great reliability is required, a grade of insulation at least equal to that called for in the following specifications should be used. The Committee does not undertake to express an opinion on the relative merits of compounds with a mineral base, and those containing organic substances.

The chemical clauses of the rubber specifications are those recommended by the Joint Rubber Insulation Committee.

The design of cables for potentials in excess of 15,000 volts is in a state of development where standardization would embarrass the manufacturers and retard progress. The Committee, has therefore, decided to make the specifications cover potentials to 15,000 volts only.

The Wire and Cable Committee of the American Electric Railway Association continues to work in collaboration with this Committee, with the result that the two associations now have substantially similar specifications.

In order to facilitate the use of the specifications, the Committee deems it advisable to reprint the entire 1913 Specification with the modifications proposed.

Part II--Order Forms

The specification (Part III) covers labor and materials for all kinds of wire and cables for railway, power and lighting purposes, but does not specify the size or make up of any particular kind of wire or cable.

It must, therefore, be supplemented by certain specific data whenever used. This may be accomplished in either of three ways.

1st. The man who is ordering wire or cable may be provided with a series of printed or mimeographed order forms which he fills out and forwards to the Purchasing Agent, who copies the filled-out form and sends it to the manufacturers.

2nd. The man who is ordering wire or cable may be provided with a series of printed or mimeographed specifications which are virtually order forms filled out for a given type, but not size, of wire. These specifications are mere descriptions of cable make-up and refer to the general specifications for details of materials and tests. When ordering wire, the proper specification is selected and sent to the Purchasing Agent with a requisition stating the size, quantity, maximum and minimum length, time and place of delivery, and approximate price.

3rd. The man who is ordering wire or cable writes out a complete specification, using in it such clauses as he requires from the General Wire & Cable Specification.

The second plan works better in practice, as it eliminates the preparation and use of a large number of more bulky and complicated specifications and the possibility of overlooking any items.

Which of the three plans should be adopted depends upon local conditions and must be decided for each individual case.

The order form system is in use by several important wire and cable users, but the second system has been found more practical for large systems.

The order forms may be backed with general advice and instructions for filling out, these being for the benefit of the men preparing orders. The Committee has not deemed it advisable to prepare such instructions on account of the impossibility of considering all the conditions to be met.

The types and sizes of wire and cable used in each department should be standardized as far as practicable and a series of properly numbered forms filled out to conform with the standards, should be kept on file in the department. These standard filled-out forms are merely copied when an order form is to be filled out for transmission to the Purchasing Agent.

Eight typical order forms follow. Probably any one user will require only two or three kinds and it may be that other forms will have to be prepared to suit local conditions.

Order Form I.

Order Form for Bare or Weatherproof Aerial Wire or Cable.

Blanks to be Filled

Items.

(a) Quantity required, feet ....
(b) Maximum length, each piece, feet..........
(c) Minimum length, each piece, feet..........
(d) Size of conductor,
    A. w. g. or ....
    Circular mils ....
(e) Material of conductor,
    hard drawn copper....................
    aluminum ....
    copper-clad steel ....
    phone-electric metal ....
(f) Solid or stranded ....
(g) Stranding, standard or special ....
(h) Number of strands (if special)..........
(i) Condition of central wire (if conductor is
    stranded), hard drawn....................
    semi-hard drawn ....
    cotton braids, each 1/32d. in. thick......
(j) Number of impregnated (weatherproof)
(k) Whether to be delivered in coils or on reels.
(l) Where to be delivered ....
(m) When to be delivered ....
(n) Approximate total cost* ....

All workmanship and materials shall conform in every respect with the requirements of the current issue of the General Wire and Cable Specifications of the Association of Railway Electrical Engineers.

---

*For the guidance of the Purchasing Agent.

Order Form II.

Order Form for Bare Conductors Not for Aerial Spans.

Blanks to be Filled

Items.

(a) Quantity required, feet ....
(b) Maximum length, each piece, feet ....
(c) Minimum length, each piece, feet ....
(d) Size of conductor (if not extra flexible)
    A. w. g. or ....
    Circular mils ....
(e) Size of each wire (if extra flexible), A. w. g..
(f) Material of conductor,
    soft-annealed copper ....
    aluminum ....
(g) tinned or not tinned ....
(h) Solid or stranded ....
(i) Stranding, standard or special..............
(j) Stranding (if special), concentric or rope
    lay ....
(k) Number of strands (if special)..............
(l) Number of wires in strand if rope lay.......
(m) Whether to be delivered in coils or on reels.
(n) Where to be delivered ....
(o) When to be delivered ....
(p) Approximate cost* ....

All workmanship and materials shall conform in every respect with the requirements of the current issue of the General Wire and Cable Specifications of the Association of Railway Electric Engineers.

---

*For the guidance of the Purchasing Agent.

Order Form III. ..

Order Form for Single Conductor Insulated Wire or Cable for Indoor Service.

Blanks to be Filled

Items.

(a) Quantity required, feet ....
(b) Maximum length, each piece, feet ....
(c) Minimum length, each piece, feet ....
(d) Size of conductor (if not extra flexible)
    A. w. g. or ....
    Circular mils ....
(e) Size of each wire (if extra flexible), A. w. g..
(f) Material of conductor,
    soft-annealed copper, or ....
    hard-drawn copper ....
(g) Tinned or not tinned ....
(h) Solid or stranded ....
(i) Stranding, standard or special..............
(j) Stranding (if special), concentric or rope
    lay ....
(k) Number of strands (if special)..............
(l) Number of wires in strand (if rope lay)...
(m) Voltage of circuit ....
(n) Separator (if any), to be yarn or tape......
(o) Insulation material,
    Grade A rubber or....................
    Code rubber, or....................
    Varnished cambric, or....................
    Impregnated paper ....
(p) Thickness of insulation (if special), inches..
(q) Tapes, rubber filled cotton, number of......
(r) Number of braids of the following kinds,
    in the order given, proceeding outward,
    Impregnated cotton braids..............
    Glazed cotton braids ....
(s) Lead sheath or no lead sheath............
(t) Whether to be delivered in coils or on reels.
(u) Where to be delivered ....
(v) When to be delivered ....
(w) Approximate total cost* ....

All workmanship and materials shall conform in every respect with the requirements of the current issue of the General Wire and Cable Specifications of the Association of Railway Electrical Engineers.

---

*For the guidance of the Purchasing Agent.

Order Form IV.

Order Form for Single Conductor Insulated Wire or Cable for Exposed Service.

Blanks to be Filled

Items.

(a) Quantity required, feet ....
(b) Maximum length, each piece, feet ....
(c) Minimum length, each piece, feet..........
(d) Size of conductor (if not extra flexible),
    A. w. g. or ....
    Circular mils ....
(e) Size of each wire (if extra flexible), A. w. g..
(f) Material of conductor,
    soft-annealed copper, or ....
    hard-drawn copper ....
(g) Solid or stranded ....
(h) Stranding, standard or special..............
(i) Stranding (if special), concentric or rope
    lay ....
(j) Number of strands (if special)..............

(k) Number of wires in strand (if rope lay)
(l) Voltage of circuit
(m) Insulation material,
    Grade A rubber
    Code rubber
    Varnished cambric
(n) Thickness of insulation (if special), inches
(o) Tapes, rubber-filled cotton, number of
(p) Number of braids of the following kinds, in the order given, proceeding outward.
    Impregnated cotton
    Impregnated hemp
(q) Lead sheath or no lead sheath
(r) Steel tape armor or no armor
(s) Jute over armor (if not wanted say "no")
(t) Pressure wire (if any), size
(u) Pressure wire (if any), location.
    Stranded with conductor, or between insulation and braids
(v) Pressure wire (if any), insulation material
(w) Whether to be delivered in coils or on reels.
(x) Where to be delivered
(y) When to be delivered
(z) Approximate cost*

All workmanship and materials shall conform in every respect with the requirements of the current issue of the General Wire and Cable Specifications of the Association of Railway Electrical Engineers.

---

*For the guidance of the Purchasing Agent.

Order Form V.

Order Form for Single Conductor Insulated Wire or Cable for Underground Conduit Service.

Blanks to be Filled

Items.

(a) Quantity required, feet
(b) Maximum length, each piece, feet
(c) Minimum length, each piece, feet
(d) Size of conductor (if not extra flexible),
    A. w. g. or
    Circular mils
(e) Size of each wire (if extra flexible), A. w. g.
(f) Voltage of circuit
(g) Insulation material.
    Grade A rubber compounds
    Impregnated paper, or
    Varnish cambric
(h) Thickness of insulation (if special), inches.
(i) Pressure wire (if any), size
(j) Pressure wire (if any), location, stranded with conductor, or between insulation and braid or sheath
(k) Pressure wire (if any), insulation material
(l) Whether to be delivered in coils or on reels
(m) Where to be delivered
(n) When to be delivered
(o) Approximate total cost*

The conductor shall be of soft-annealed copper with standard stranding. The insulated conductor shall be enclosed in a lead sheath.

All workmanship and materials shall conform in every respect with the requirements of the current issue of the General Wire and Cable Specifications of the Association of Railway Electrical Engineers.

---

*For the guidance of the Purchasing Agent.

Order Form VI.

Single Conductor Submarine and Other Armored Cables.

Blanks to be Filled

Items.

(a) Quantity required, feet
(b) Maximum length, each piece, feet
(c) Minimum length, each piece, feet
(d) Size of conductor,
    A. w. g. or
    Circular mils
(e) Number of strands, each conductor (if special)
(f) Voltage of circuit
(g) Insulation, material,
    Grade A rubber, or
    Varnished cambric
(h) Thickness of insulation (if special), inches
(i) Pressure wire (if any), size
(j) Pressure wire (if any), location, stranded with conductor, or between insulation and braid or sheath
(k) Pressure wire (if any), insulation material
(l) Tapes, rubber filled cotton, number of
(m) Impregnated cotton braids, number
(n) Lead sheath or no lead sheath
(o) Thickness of sheath (if special), inches
(p) Armor, steel wire or steel tape
(q) Jute over armor (if not wanted, say "no").
(r) Whether to be delivered in coils or on reels.
(s) Where to be delivered
(t) When to be delivered
(u) Approximate total cost*

The conductor shall be of soft-annealed copper. All workmanship and materials shall conform in every respect with the requirements of the current issue of the General Wire and Cable Specifications of the Association of Railway Electrical Engineers.

---

*For the guidance of the Purchasing Agent.

Order Form VII.

Order Form for Single Conductor Wires and Cables for Train Lighting.

Blanks to be Filled

Items.

(a) Quantity required, feet
(b) Maximum length, each piece, feet
(c) Minimum length, each piece, feet
(d) Size of conductor, A. w. g.
(e) Number of strands
(f) Voltage of circuit
(g) Separator (if any), to be yarn or tape
(h) Thickness of insulation, inches
(i) Tapes, rubber filled cotton, number of
(j) Number of impregnated cotton braids
(k) Whether to be delivered in coils or on reels.
(l) Where to be delivered
(m) When to be delivered
(n) Approximate total cost*

The conductor shall be of tinned soft-annealed copper, and shall be insulated with grade A rubber.

All workmanship and materials shall conform in every respect with the requirements of the current issue of the General Wire and Cable Specifications of the Association of Railway Electric Engineers.

---

*For the guidance of the Purchasing Agent.

Order Form VIII.

Order Form for Multiple Conductor Cable.

Blanks to be Filled

Items.

(a) Quantity required, feet
(b) Maximum length, each piece, feet
(c) Minimum length, each piece, feet
(d) Number of conductors
(e) Size of each conductor (if not extra flexible),
    A. w. g. or
    Circular mils
(f) Size of each wire (if extra flexible), A. w. g.
(g) Stranding, standard or special
(h) Stranding (if special), concentric or rope lay
(i) Number of strands in conductor (if special).
(j) Number of wires in strand (if rope lay)
(k) Voltage between conductors
(l) Voltage from conductors to ground
(m) Separator (if any), to be yarn or tape
(n) Insulation over each conductor, material
    Grade A rubber, or
    Code rubber, or
    Varnished cambric, or
    Impregnable paper
(o) Thickness of insulation over each conductor (if special), inches
(p) Covering over each insulated conductor,
    Rubber-filled cotton tape, or
    Impregnated cotton braid, or

Glazed cotton braid ....
(q) Tracer in each layer of conductors (state whether required) ....
(r) If braids are to be differently colored as tracers, state sequence of colors........
(s) Jute laterals (state whether required).......
(t) Pressure wire (if any), side A. w. g.........
(u) Tape over each layer of conductors (if required), material
  Rubber-filled cotton, or ....
  Dry cotton, or........................
  Impregnated paper, or ....
  Dry paper, or ....
  Varnished cambric ....
(v) Insulation over all conductors, i. e., belt (if any) material,
  Grade A rubber, or ....
  Varnished cambric, or ....
  Impregnated paper ....
(w) Thickness of insulation belt (if special), inches ....
(x) Tape over finished group of conductors (or over belt if any), material,
  Impregnated cotton, or ....
  Varnished cambric ....
(y) Jute filler under braid or sheath (state whether required ....
(z) Jute filler (if other than 8-ply), state size required ....
(aa) Number of braids of each of the following kinds in the order given, proceeding outward,
  Impregnated cotton braids ....
  Glazed cotton braids ....
  Impregnated hemp braids ....
(ab) Lead sheath or no sheath ....
(ac) Thickness of sheath (if special), inches....
(ad) Armor (if any), steel wire or steep tape..
(ae) Jute over armor (if not wanted, say "no")..
(af) Maximum overall diameter (if limit is necessary), inches ....
(ag) Whether to be delivered in coils or on reels
(ah) Where to be delivered ....
(ai) When to be delivered ....
(aj) Approximate total cost* ....

The conductors shal be of soft-annealed copper, tinned if rubber insulated, otherwise not tinned. The insulation of the pressure wire, if any, shall be of the same material as on the main conductors. Two conductor cables shall be flat unless otherwise specified. If there are more than two conductors, they shall be assembled helically.

All workmanship and materials shall conform in every respect with the requirements of the current issue of the General Wire and Cable Specifications of the Association of Railway Electrical Engineers.

---

*For the guidance of the Purchasing Agent.

Part III--General Specifications

(These specifications are to be sent to the manufacturers yearly and are merely referred to when ordering wire or cable:)

General Clauses.

1. (a) **Workmanship and Materials:** All workmanship and materials shall be the best of their respective kinds and shall be in full accord with the best modern engineering practice.

(b) **Inspection:** The wire or cable shall be open for inspection by an authorized representative of the purchaser, who shall be afforded all necessary facilities to assure him that the materials used, and the process of manufacture, conform with the specifications. In the cases of conductors insulated with rubber compound with any kind of covering and conductors insulated with varnished cloth covered with dry or flameproof braid, the braid or sheath shall not be applied until the inspector has approved (in writing) the insulations. All other wires and cables will be inspected in their completed form.

(c) **Notification:** The contractor shall notify the designated representative of the purchaser sufficiently in advance of the completion of the wire and cable to enable inspection to be arranged for.

(d) **Factory Tests:** The manufacturer shall furnish suitable apparatus and shall make the tests in the presence of the railroad company's representative, who shall be allowed every reasonable facility to assure himself that the requirements of this specification have been complied with, except that when chemical analysis of rubber insulation is required it shall be made by the purchaser.

(e) **Definition of Cable Size:** The combined area of the wires when laid out straight and measured at right angles to their axes shall be not less than the specified gauge or circular mils. Unless otherwise specified, conductors shall be soft-annealed copper.

(f) **Thickness of Insulation:** Unless otherwise specified the thickness of insulation for potentials up to 7,000 volts, shall be the minimum allowed by the National Board of Fire Underwriters, as summarized in Table I. For higher voltages, the thickness of insulation will depend upon the conditions of service.

TABLE I.

THICKNESS OF INSULATION RECOMMENDED BY THE NATIONAL BOARD OF FIRE UNDERWRITERS

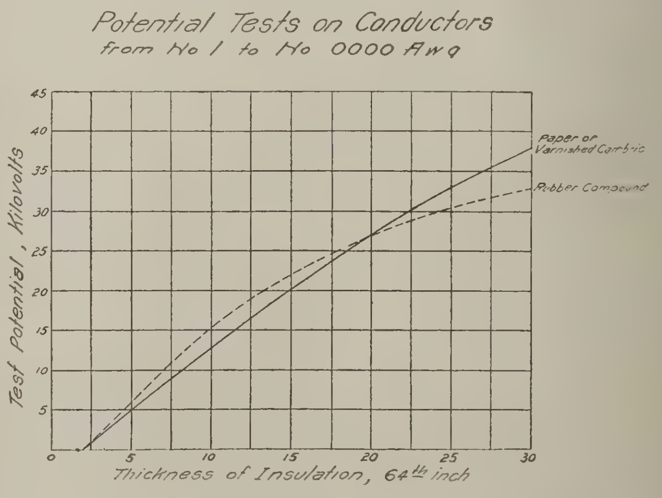
	Working Voltage					
	0–600	1,500	2,500	3,500	5,000	7,000
Cir. Mills	Thickness of Insulation, 64ths Inch					
2,000,000	8	9	10	11	14	18
1,750,000	8	9	10	11	14	18
1 500,000	8	9	10	11	14	18
1,250 000	8	9	10	11	14	18
1,000 000	7	8	9	10	12	16
900,000	7	8	9	10	12	16
800,000	7	8	9	10	12	19
700,000	7	8	9	10	12	16
600,000	7	8	9	10	12	16
500 000	6	7	8	9	12	16
400,000	6	7	8	9	12	16
300,000	6	7	8	9	12	16
225,000	6	7	8	9	12	16
A. W. G. or B. & S.						
0000	5	6	7	8	12	16
000	5	6	7	8	12	16
00	5	6	7	8	12	16
0	5	6	7	8	12	16
1	5	6	7	8	12	16
2	4	5	6	8	12	16
4	4	5	6	8	12	16
6	4	5	6	8	12	16
8	3	4	6	8	12	16
10	3	4	6	8	12	16
12	3	4	6	8	12	16
14	3	4	6	8	12	16

(g) **Stranding:** Unless otherwise specified, the stranding shall be concentric and in accordance with the following table:

TABLE II.

Range of Sizes	Minimum Number of Wires in Conductor
2,000,000—1,600,000 Circ. Mills	127
1,500,000—1,100,000	91
1,000,000— 550,000	61
500,000— 250,000	37
No. 0000—No. 1 A. W. G. or B. & S.	19
2— 8	7
Smaller Sizes	1

(h) **Repairs and Joints of Insulation:** If exigencies of manufacture require repairs or joints in the insulation, the work shall be done in such a way as to leave the repair part or joint, and all parts affected by it, as strong and durable electrically as the remainder of the insulation. In the



case of rubber insulation, patches and joints shall be properly vulcanized.

Electrical Tests.

2. (a) **High Potential Tests.** The high potential test voltage shall be applied for five (5) minutes, shall have a frequency not exceeding one hundred (100) cycles per second, and shall approximate as closely as possible to sine wave. The source of energy shall be of ample capacity.

TABLE IV.
TEST POTENTIALS, KILOVOLTS
Five-Minute Tests

Rubber—Use 100 per cent of following potentials.
Varnish Cloth—Use 75 per cent of following potentials.
Impregnated Paper—Use 75 per cent of following potentials.

Size of Conductors	Thickness of Insulation, 64ths Inch							
	2	3	4	5	6	7	8	10
2,000,000 C. M.	....	....	....	....	....	....	5.0	10.5
1,750,000	....	....	....	....	....	....	6.5	11.5
1,500,000	....	....	....	....	....	....	7.0	12.0
1,250,000	....	....	....	....	....	....	7.5	12.5
1,000,000	....	....	....	....	....	5.5	8.0	13.0
750,000	...	....	....	....	....	6.5	9.0	14.0
500,000	....	....	....	2.5	5.0	7.5	10.0	14.5
250,000	....	....	....	4.0	6.5	9.0	11.0	15.5
0000 A. W. G. or B. & S.	....	....	....	4.5	7.0	9.0	11.5	15.5
000	....	....	....	5.0	7.5	9.5	11.5	15.5
00	....	....	....	5.0	7.5	9.5	11.5	15.5
0	....	....	....	5.5	8.0	10.0	12.0	15.5
2	....	....	4.0	6.0	8.0	10.0	12.0	15.0
4	....	....	4.5	6.5	8.5	10.0	11.5	14.5
6	....	....	5.0	6.5	8.5	10.0	11.5	14.0
8	....	3.0	5.0	7.0	8.0	9.5	11.0	13.0
10	....	3.0	5.0	6.5	8.0	8.5	10.0	12.0
12	....	2.5	5.0	6.0	7.5	8.5	9.5	11.5
14	....	2.5	5.0	6.0	7.0	8.0	9.0	11.0
16	1.0	2.5	4.5	5.5	6.5	7.5	8.5	10.5
18	1.0	2.5	4.5	5.5	6.5	7.5	8.5	10.5

(For intermediate sizes use the voltages corresponding to the next larger size, having the same thickness of insulation.)

TABLE V.
TEST POTENTIALS, KILOVOLTS

		Thickness of Insulation, 64ths Inch								
		12	14	16	18	20	22	24	26	28
250,000 and larger	Rubber	19	22	24	26	28	30	31	33	34
	V. C. or Paper	17	20	23	25	28	31	33	36	38
1-0000 A. W. G. or B. & S.	Rubber	18	21	23	25	27	28	30	31	32
	V. C. or Paper	16	19	22	24	27	30	32	34	36
4-2 A. W. G. or B. & S.	Rubber	17	19	22	24	25	26	28	29	30
	V. C. or Paper	15	17	20	23	25	28	30	32	34
6-5 A. W. G. or B. & S.	Rubber	16	18	20	22	23	25	26	28	29
	V. C. or Paper	15	17	19	21	23	26	28	30	31

(b) **Insulation Resistance:** The (apparent) insulation resistance shall be measured after the high potential test, and shall be tested after a one-minute electrification with a battery having an e. m. f. of not less than 150 and not more than 500 volts, and the results corrected to the standard temperature of 15.5 deg. cent. (60 deg. Fahr.)

Copper, Soft, Semi-Hard and Hard Drawn.

3. The current issue of the specifications of the American Society for Testing Materials shall be complied with in every respect. Sufficient data on the conductivity of tinned wire not being available, allowance will be made in conductivity by the inspector.

Tinning.

4. Tinned wire shall be provided with a heavy uniform coating of commercially pure tin without projections. Where tinned wire is supplied but not called for, the following test is not required.

Samples of wire, before stranding or covering, shall be thoroughly cleaned with alcohol and immersed in hydrochloric acid of specific gravity 1.088 and temperature 15.5 deg. cent. (60 deg. Fahr.) for one minute. They shall then be rinsed in clear water and immersed in a solution of sodium sulphide of specific gravity 1.142 for 30 seconds and again washed. This operation shall be repeated three times and upon the completion of the fourth cycle the sample shall show no sign of blackening.

The sodium sulphide solution shall contain an excess of sulphur and shall have sufficient strength to thoroughly blacken a piece of clean untinned copper wire in five seconds.

Separator.

5. The separator may consist of soft cotton yarn (which may be braided), or of paper or muslin tape. With untinned conductor to prevent the conductor sliding in the insulation. ductors; with tinned conductors, it is desirable that the separator shall allow the insulation sufficient contact with the conductor to prevent the conductor sliding in the insulation.

Grade A Rubber Compound.

6. (a) **Composition:** The compound shall consist of Fine Para or Smoked First Latex Hevea rubber and a mineral base. It shall contain only the following ingredients:

Rubber.
Sulphur.
Inorganic mineral water.
Refined solid paraffin or ceresin.

It shall not contain either red lead or carbon.

(b) **Results of Analysis:** After vulcanization, the compound shall conform to the following requirements, the results to be expressed as percentages of the whole sample:

Rubber, between	30 and 33% by wt.
Waxy Hydrocarbons, under	4
Free Sulphur, under	0.7

After vulcanization the compound shall conform to the following requirements, results to be taken between the limits given, in proportion to the percentage by weight of rubber found:

TABLE VI.
MEGOHM-MILES AT 15.5° C. (60° F.) BASED UPON THE CONSTANT 4,000
1 MINUTE ELECTRIFICATION.

Rubber, minimum shall be 100% of following.
Varnished Cloth, minimum shall be 15% of following.
Impregnated Paper, minimum shall be 12½% of following.

Size of Conductors	Thickness of Insulation, 64ths Inch															
	2	3	4	5	6	7	8	10	12	14	16	18	20	22	24	26	28
2,000,000 C. M.	....	....	....	....	....	....	200	275	325	425	....	....	....	....	....	....	....
1,750,000	....	....	....	....	....	....	275	300	375	450	....	....	....	....	....	....	....
1.500,000	....	....	....	....	....	....	300	325	400	475	....	....	....	....	....	....	....
1,250,000	....	....	....	....	....	....	325	375	425	500	575	....	....	....	....	....	....
1,000,000	....	....	....	....	....	300	325	400	475	550	625	....	....	....	....	....	....
750,000	....	....	....	....	....	325	400	475	525	625	700	775	....	....	....	....	....
500,000	....	....	....	300	375	400	475	575	675	750	850	900	....	....	....	....	....
350,000	....	....	....	350	425	475	525	675	775	850	950	1050	1125	....	....	....	....
250,000	....	....	....	400	475	575	625	725	875	1000	1100	1200	1275	....	....	....	....
0000 A. W. G. or B. & S.	....	....	....	450	550	600	650	800	950	1050	1150	1250	1350	1450	....	....	....
000	....	....	....	500	600	650	750	850	1000	1150	1250	1350	1450	1550	....	....	....
00	....	....	....	550	650	750	850	950	1050	1250	1350	1500	1600	1700	1800	....	....
0	....	....	....	600	700	800	950	1050	1200	1350	1500	1600	1700	1800	1900	2000	....
1	....	....	600	650	750	850	1000	1150	1350	1450	1600	1750	1850	1950	2050	2150	2250
2	....	....	650	750	850	950	1050	1250	1450	1600	1700	1850	1950	2100	2200	2300	2400
4	....	....	750	850	1000	1150	1250	1450	1650	1850	2000	2150	2250	2400	2500	2600	2700
6	....	....	850	1050	1200	1350	1450	1750	1950	2100	2300	2450	2550	2700	2800	2900	3000
8	....	850	1050	1250	1450	1650	1750	2050	2200	2400	2600	2750	2900	3050	3150	3250	3350
10	....	1150	1350	1600	1800	2000	2150	2400	2650	2900	3100	3250	3400	3550	3700	3800	3900
12	....	1350	1600	1850	2050	2250	2400	2750	3000	3250	3400	3600	3750	3900	4050	4150	4300
14	....	1550	1850	2150	2350	2550	2650	3050	3350	3550	3800	3950	4100	4300	4400	4550	4650
16	1400	1800	2150	2400	2650	2850	3050	3400	3650	3950	4150	4350	4500	4650	4800	4900	5050
1	1600	2050	2450	2800	3000	3200	3400	3750	4050	4300	4500	4700	4900	5000	5150	5300	5400

Limits allowed for 30% Rubber Compound.

	Maximum	Minimum
Saponifiable extract	1.35	0.55%
Unsaponifiable resins	0.45	....
Chloroform extract	0.90	....
Alcoholic potash extract	0.55	....
Total sulphur (see note)...............	2.10	....
Specific gravity	...	1.75%

Limits allowed for 33% Rubber Compound.

	Maximum	Minimum
Saponifiable extract	1.50	0.60%
Unsaponifiable resins	0.50	....
Chloroform extract	1.00	....
Alcoholic potash extract	0.60	....
Total sulphur (see note)...............	2.30	....
Specific gravity	...	1.67%

The acetone solution extract shall not fluoresce.

The acetone extract (60 cc.) shall be not darker than a light straw color.

Hydrocarbons shall be solid, waxy, and not darker than a light brown.

Cloroform extract (60 cc.) shall be not darker than a straw color.

Contamination of the compound, such as by the use of impregnated tapes, will not excuse the manufacturer from conforming to this specification.

Failure to meet any requirement of this specification will be considered sufficient cause for rejection.

The compound wil be analyzed by the procedure recommended by the Joint Rubber Insulation Committee.

Note—The limit on total sulphur may be omitted by the Purchaser if he desires to admit sulphur bearing fillers. See Report of Joint Rubber Insulation Committee, Proc. A. I. E. E. January, 1914.

(c) **Concentric Application:** The conductor shall be tinned. The compound shall be applied concentrically about the conductors and shall fit tightly thereto. Where the installation is applied in more than one layer, adjacent layers shall adhere firmly. If necessary, in order to achieve this result on insulated conductors of greater diameter than 0.3 inch of an inch over the insulation, a tape shall be applied over the insulation before vulcanization. Such tape, if it does not comply with the tape specification given hereinafter, will be additional to any which may be required in the acompanying wire specification form.

(d) **Tensile Strength and Elongation:** A sample which may be of entire, segmental, or approximately rectangular cross-section, at the discretion of the manufacturer, shall be cut from the insulated conductor by means of a sharp knife. The sample shall be bent in every direction to magnify and reveal any surface incision or imperfection which may exist. A portion of the sample without such defects and having a free length of not less than two inches, shall then be stretched at the rate of twelve inches per minute, until it breaks. The marks shall be placed on the insulation before its removal from the conductor. Five samples from every 25,000 feet or less shal be tested in this way. Tensile strength and elongation tests shall be made on unstretched samples.

The compound shall conform to the following limits:

TABLE VII.

Property	Thickness Inches			
	12/64-in or less		Over 12/64-in.	
	Maximum	Minimum	Maximum	Minimum
Tensile strength, lbs. per sq. in. (each sample)...........................	....	1000	....	1000
Elongation in two (2) in. length at break (times original length)................	....	5	....	4
Elongation 5 seconds after release when stretched at the rate of 12 in. per minute to 3 times its length...........	20%	....	20%	....

(e) **Electrical Tests:** Electrical tests shall be made upon rubber insulated wire or cable after at least twelve hours immersion in water, while still immersed and before the application of any covering other than the tape used in vulcanization. The insulated conductor shall successfully meet the high potential tests specified in Tables IV and V. In the case of multiplex cables, the high potential test shall be made and the insulation resistance shall be measured before assembling the conductors. An additional electrical test shall be made on lead covered or armored cable and shall consist of a high potential test to be made upon the cable after assembling and leading or armoring and, if lead covered, without immersion in water. In the case of multiplex cables, this manila paper applied helically, firmly and evenly to the con-

test shall be made successively between each conductor and the other conductors and sheath in multiple.

The apparent insulation resistance shal be not less than is given in Table VI.

The insulation resistance (megohms) at a given temperature shall be reduced to that at 15.5 deg. cent. (60 deg. Fahr.) by dividing by the coefficient in Table VIII corresponding to that temperature.

TABLE VIII.

(Tests shall be made at temperatures within the scope of this table.)

Temperature Cent. Degrees	Coefficient Shall Not Be Greater Than	Temperature Degrees Cent.	Coefficient Shall Be Not Less Than
7	1.53	16	0.98
8	1.45	17	0.93
9	1.37	18	0.89
10	1.30	19	0.85
11	1.23	20	0.81
12	1.17	21	0.77
13	1.12	22	0.73
14	1.07	23	0.70
15	1.02	24	0.67
15.5	1.00	25	0.64

(Tests shall be made at temperatures within the scope of this table).

Temperature Degrees Fahr.	Coefficient Shali Be Not Greater Than	Temperature Degrees Fahr.	Coefficient Shall Not Be Less Than
46	1.44	60	1.000
47	1.41	61	.974
48	1.37	62	.949
49	1.34	63	.925
50	1.30	64	.901
51	1.27	65	.878
52	1.24	66	.855
53	1.20	67	.833
54	1.17	68	.812
55	1.14	69	.791
56	1.11	70	.771
57	1.09	71	.751
58	1.06	72	.732
59	1.03	73	.713
60	1.00	74	.695
	..	75	.677

Varnished Cloth Insulation.

7. (a) **Description:** The insulation shall consist of a closely woven cotton cloth and a viscous filler. Each surface of the cloth shall have smooth, continuous films of varnish and shall be free from wrinkles, blisters, and all other imperfections. It shall be thoroughly impregnated with insulating compound, shall be pliable and shall have no tendency to crack when doubled on itself.

(b) **Filler:** The filler shall be a viscous, moisture-repelling insulating compound, whose dielectric constant is similar to that of the varnished cloth insulation and of such a nature as to have no deleterious effect upon the varnish. It shall also prevent the tapes from unwrapping when cut, but will allow the layers to slide upon each other when the cable is bent.

(c) **Assembly:** The insulating cloth shall be applied in the form of tape wound on helically and reversed at least every two layers. The tapes shall be of such widths that for different diameters of cable they will lie smoothly and be free from wrinkles; the turns shall overlap and the joints in successive layers shall be staggered. The filler shall be so applied between layers as to exclude all air, the whole forming a hard, semi-flexible wall of insulation.

(d) **Tape:** A layer of cloth tape thoroughly filled with a rubber compound lapping one-fourth of its width shall be applied over the cloth insulation.

(e) **Electrical Tests:** Each and every length of cable shall meet the specified electrical tests. Wire or cable to be covered with dry or flameproof braid shall be tested after twelve hours immersion in water and before the braid is applied; if it is to be covered with weatherproof braid, the tests shall be made on the finished product. Lead covered conductors shall be tested against the sheath with sheath grounded. Multiplex cables shall be tested between each conductor and the other conductors and sheath or ground in multiple.

(f) **Temperature Coefficient:** At whatever temperature the cable may be tested, the megohms shall be not less than specified in Table IX. Should a cable tested in air fail to meet the above requirements, the manufacturer may immerse the cable in water to obtain a constant temperature.

Impregnated Paper Insulation.

8. (a) **Description:** The insulation shall consist of a manila paper applied helically, firmly and evenly to con-

TABLE IX.

(Tests shall be made at temperatures within the scope of this table).

Temperature		Coefficient Shall Be Not Greater Than	Temperature		Coefficient Shall Be Not Less than
Degrees Cent.	Degrees Fahr.		Degrees Cent.	Degrees Fahr.	
4.5— 7.2	40—45	2.0	16.1—18.3	61— 65	0.7
7.7—10.0	46—50	1.5	18.8—21.1	66— 70	0.5
10.5—12.7	51—55	1.2	21.6—23.8	71— 75	0.4
13.3—15.5	56—60	1.0	24.4—26.6	76— 80	0.3
			27.2—29.4	81— 85	0.2
			30.0—32.2	86— 90	0.15
			32.7—35.0	91— 95	0.10
			35.5—37.7	96—100	0.05
			38.3—40.5	101—105	0.03

ductor, and then thoroughly impregnated with an insulating compound. The cable shall be pliable and shall show no tendency to harden injuriously at 0 deg. cent.

(b) **Paper:** The paper shall contain no free acids or free alkalis. Tensile strength tests shall be made upon paper taken from the finished cable, both from conductor and jacket, if any. Test pieces ten feet in length shall be selected looped and tension applied at the loop through a mandrel, the diameter of which is equal to the width of the paper. The test shall be as follows:

5,000 pounds per square inch for 5 minutes, and then 6,500 pounds per square inch for 1 minute.

Acceptance shall be based upon the average of six tests on samples selected at random from each order by the inspector.

(c) **Compound:** The compound shall be applied so as to exclude all air and moisture and shall contain no free mineral acid or other substances which have a deleterious effect upon paper.

(d) **Electrical Tests:** Each and every length of cable shal conform to the specified electrical tests. No immersion is required before testing. The potential test shall be made between conductor and sheath with the sheath grounded. Multiplex cables shall be tested between each conductor and sheath or ground, in multiple.

Braids.

9. (a) **Description:** Braid shall be closely woven of cotton thread, at least two-ply, thoroughly impregnated with an insulating waterproof compound and finished with a black insulating compound thoroughly slicked down. The compound shall be neither injuriously affected by nor have injurious effect upon the braid at a temperature of 90 deg. cent. (194 deg. Fahr.) The thickness shall be not less than given in the following table:

TABLE X.

Diameter Over the Insulation, Inches	Thickness of Braid, Inches, Not Less Than
.160	.018
.290	.028
.530	.038
1.000 and over	.053

For intermediate diameters use next smaller diameter.
Note.—The above does not apply to fancy or special braids for fixtures, etc.

(b) **Tests:** A six inch sample of wire with carefully paraffined ends shall be weighed and submerged in fresh water of a temperature of 20 deg. cent. (68 deg. Fahr.) for a period of twenty-four hours. The increase in weight after submersion and removal of surface water shall be not more than 9 per cent of the weight exclusive of copper and insulation before submersion. The compound shall not drip at a temperature of 50 deg. cent. (122 deg. Fahr.).

Rubber Filled Cloth Tape.

10. The tape shall consist of a cotton cloth not lighter than one pound per four yards 36 inches wide with not less than 56x60 picks per inch, thoroughly filled with a rubber compound. The tape shall be applied spirally, overlapping not less than specified in Table XI, which also gives the maximum width of tape allowed:

TABLE XI.

Diameter Over Insulation, Inches	Maximum Width of Tape, Inches	Minimum Overlap Inches
2.00	5	½
1.75	4—½	½
1.50	4	½
1.25	3—½	½
1.15	3—¼	½
1.00	3	½
.88	2—¾	⅜
.75	2—⅜	⅜
.62	2	⅜
.44	1—¾	⅜
.38	1—½	¼
.31	1—¼	¼
.25	1	¼
.19	⅞	⅛
.16	¾	⅛

For intermediate diameters use next smaller diameter.

Sheath.

11. (a) **Thickness:** Unless otherwise specified, the sheath shall have an average thickness of not less than that indicated in Table XII, and the minimum thickness shall in no place be less than 90 per cent of the required average thickness.

TABLE XII.

Diam. o Core Inches	Corresponding Thickness of Sheath in Inches. Paper Insulation	Rubber or Var. Cloth Insulation
—0.29	5/64	4/64
0.30—0.69	6/64	5/64
0.70—1.24	7/64	6/64
1.25—1.99	8/64	7/64
2.00—2.69	9/64	8/64
2.70—over	10/64	9/64

For intermediate diameter use next smaller diameter.

(b) **Composition:** The sheath shall consist of commercially pure lead for all cables having a core diameter (i. e., internal diameter of the sheath) less than two inches; for cables having a core diameter equal to two inches or more the sheath shall consist of an alloy of lead and commercially pure tin containing not less than one per cent of tin.

Wire Armor.

12. If the cable is rubber insulated, it shall be covered with tape, braid, or other suitable protection before passing through the asphalt compound.

(a) **Armor:** The core of the cable shall be run through a hot asphalt compound, served with a layer of jute yarn, run through hot asphalt again, and then laid with galvanized wire armor.

(b) **Size of Armor Wire:** The proper size of armor wire will depend upon the conditions of service; the latitude allowed in the following table represents the difference arising from such difference in service conditions. Unless otherwise specified, the armor wire shall be the minimum size.

TABLE XIII.

Diameter of Cable Under Jute Bedding, Inches	Armor Wire Steel Wire Gauge*	Jute Bedding Under Armour Measured in Finished Cable, Inches
0.00—0.50	14—13	2/32 minimum
0.44—0.69	12	2/32
0.63—1.00	10	2/32
0.88—1.50	8	2/32
1.25—2.00	6	2/32
1.30—larger	4	2/32

*The same number wire on the Birmingham Wire Gauge will be acceptable. The Steel Wire Gauge is described in Circular No. 31 of the Bureau of Standards the corresponding diameters being as follows:

Steel Wire Gauge No.	Diameter, Mils
4	225.3
6	192.0
8	162.0
10	135.0
12	105.5
13	91.5
14	80.0

(c) **Lay:** The armor shall be applied closely within appreciable space between adjacent wires. The lay shall be from eight to twelve times the pitch diameter.

(d) **Finish:** The armored cable shall be run through hot asphalt compound, served with a layer of the best three-ply 14 lb. hard twisted jute yarn spun in a close short lay, run through hot asphalt compound, then served with a second layer of three-ply, 14 lb. jute yarn, run through hot asphalt compound and finally run through some material to prevent sticking.

(Under certain conditions, the purchaser may find it advisable to specify the omission of the outer jute covering.)

(e) **Direction of Lay:** Successive layers of jute or jute and armor shall be laid in opposite directions. In the case of multiple conductor cable armored without lead, the outside layer of conductors shall be put on with a right hand lay. The armor shal be put on with a left hand lay.

(f) **Definition of Lay:** The direction of lay is defined as the laterial direction in which the wires run over the top of the cable as they recede from an observer looking along the axis of the cable.

(g) **Armor Wire:** The armor wire shall consist of a galvanized mild steel wire of uniform diameter, free from all cracks, splits or other flaws. Samples shall be taken (at random) from ten per cent of the coils to be used for each of the following tests. At least 80 per cent of the samples shall fulfill the conditions of the test in order that the whole lot may be considered satisfactory.

(h) **Tensile Strength Test:** The wire must have a tensile strength of 50,000 pounds per square inch and an elongation of not less than ten per cent in eight inches.

(i) **Galvanizing Test:** Thoroughly clean a sample to remove all dirt and grease, rinse in clean water and wipe dry with a clean cloth or cotton waste. Immerse for one minute in a solution of copper sulphate of specific gravity 1.186 at 18.3 deg. cent. (65 deg. Fahr.), rinse in clean water and wipe dry. Repeat this operation until the samples have been immersed four times. After these immersions no sample shall show any bright deposit of copper. The samples shall be approximately straight and the ends protected with paraffin. The solution shall be saturated with copper sulphate to which an excess of C. P. cupric oxide has been added and shall be maintained at 15.5-20 deg. cent. (60-68 deg. Fahr.) during the test.

(j) **Flexibility Test:** The armor wire shall admit of bending around a spindle of ten times the diameter of the wire and back again without developing cracks of the galvanizing which are visible to the naked eye.

Steel Tape Armor.

13. (a) **Description:** The core of the cable shall be run through a bath of hot asphalt compound, served with a layer of jute yarn spun on with a close short lay, run through hot asphalt compound, armored with a steel tape; armored with a second steel tape; run through hot asphalt compound, served with a layer of 3-ply, 14 pound jute yarn with a close short lay, run through hot asphalt compound and finished by running through some material to prevent sticking. Both steel tapes shall be laid in the same direction and the outer shall be centered over the spaces between turns of the inner. If the cable is rubber insulated, it shall be covered with tape, braid, or other suitable protection before passing through the asphalt compound. Each layer of jute shall be applied in the reverse direction to the adjacent layer. The space between adjacent turns of steel tape shall not exceed one-tenth the width of the steel tape.

(b) **Armored Tape:** The galvanized tape and the jute, under the armor, after armoring, shall conform to the following table:

Cable Reels:

VABLE XIV.

Cable Diameter Before Armoring Inches	Maximum Width Steel Tape, Inches	Minimum Thickness Each Tape, Inches	Minimum Jute Bedding, Under Armor Measured in Finished Cable, Inches
—0.45	½	0.02	2/32
0.46—0.75	¾	0.02	2/32
0.76—1.00	1	0.03	2/32
1.01—1.40	1—¼	0.03	2/32
1.41—1.70	1—½	0.04	2/32
1.71—2.00	1—¾	0.04	2/32
2.01—over	2	0.05	2/32

14. (a) **General:** Each reel shall consist of a wooden drum with wooden discs or heads securely fastened thereto.

(b) **Bushings:** Each disc or head of the reel shall be provided with an iron plate or cast iron bushing in the center of which shall be a hole two and one-half inches in diameter. The plates or bushings shall be secured to the head by means of bolts or lags through the head.

(c) **Covering:** Insulated cable shall be thoroughly covered with burlap before lagging is applied.

(d) **Lagging:** When used for insulated cable the reels shall be suitably lagged; when used for bare cable, the lagging of the reel shall be replaced by a burlap covering securely bound to the cable.

(e) **Chocking:** Reels shall be properly chocked in the car so that there shall be no movement of reels during transit.

Part IV--Terminology

The following terminology which should be used in specification and orders is recommended by the American Institute of Electrical Engineers, in their Standardization Rules:

Definitions.	**Remarks.**
1. **Wire:** A slender rod or filament of metal.	The definition restricts the term to what would ordinarily be understood by the term solid wire. The word "slender" is used in the general sense of long in comparison with the diameter. If the wire is covered with insulation, it is properly called an insulated wire; while primarily the term **wire** refers to the metal, nevertheless when the context shows that the wire is insulated the term wire will be understood to include the insulation.
2. **Conductor:** A wire or combination of wires not insulated from one another, suitable for carrying a single electric current.	The term **conductor** is not to include a combination of conductors insulated from one another, which would be suitable for carrying several different electric currents. Rolled conductors (such as busbars) are, of course, conductors, but are not considered under the terminology here given.
3. **Stranded Conductors:** A conductor composed of a group of wires or any combination of groups of wires.	The wires in a stranded conductor are usually twisted or braided together.
4. **Cable:** (1) A stranded conductor (single-conductor cable), or (2) a combination of conductors insulated from one another (multiple-conductor cable).	The component conductors of the second kind of cable may be either solid or stranded, and this kind of cable may or may not have a common insulating covering. The first kind of cable is a single conductor, while the second kind is a group of several **conductors.** The term **cable** is applied by some manufacturers to a solid wire, heavily insulated and lead-covered; this usage arises from the manner of the insulation, but such a conductor is not included under this definition of "cable," and should be avoided. The term "cable" is a general one, but in practice it is usually applied only to the larger sizes. A small cable is called a "stranded wire" or a "cord," both of which are defined below. Cables may be bare or insulated, and the latter may be armored with lead or with steel wires or bands. In all cases, a cable is a complete conductor, not a part of one.
5. **Strand:** One of the wires or groups of wires of any stranded conductor.	Some American wire manufacturers use the word strand to designate a group of wires twisted together, but this use should be discouraged.
6. **Stranded Wire:** A group of small wires used as a single wire.	There is no sharp dividing line of size between a "stranded wire" and a "cable." If used as a wire, for example, in winding inductance coils or magnets, it is called a stranded wire and not a cable. If it is substantially insulated, it is called not a stranded wire, but a "cord" defined below.
7. **Cord:** A small cable, very flexible and substantially insulated to withstand wear.	There is no sharp dividing line between a "cord" and a "cable," and likewise no sharp dividing line in respect to the character of insulation between a "cord" and a "stranded wire."
8. **Concentric Strand:** A strand composed of a central core surounded by one or more layers of helically laid wires or groups of wires.	
9. **Concentric Lay Cable:** A concentric strand used as a complete cable.	
10. **Concentric Rope Lay Cable:** A cable composed of a central core surrounded by one or more layers of helically laid groups of wires.	This is a special case of the concentric lay cable defined.
11. **N-Conductor Cable:** A combination of N-conductors insulated from one another.	It is not intended that the name as here given be actually used. One would, instead, speak of a 3-conductor cable, a 12-conductor cable, etc. In referring to the general case, one may speak of a "multiple-conductor cable."
12. **N-Conductor Concentric Cable:** A cable composed of an insulated central conducting core with (N-1) tubular stranded conductors laid over it concentrically and separately by layers of insulation.	Usually only 2-conductor or 3-conductor. Such conductors are used in carrying alternating currents. The remarks on the expression "N-Conductor" given for the preceding definition, apply here also.
13. **Duplex Cable:** Two insulated single-conductor cables twisted together, having a common covering.	The term duplex is used by some manufacturers to describe twin cable.
14. **Twin Cable:** Two insulated single-conductor cables laid parallel, having a common covering.	
15. **Duplex Wire:** Two small insulated conductors twisted together. They may or may not have a common covering.	

16. **Twin Wire:** Two small insulated conductors laid parallel, having a common covering.

17. **Triplex Cable:** Three insulated single-conductor cables twisted together. They may or may not have a common covering.

W. A. Del Mar, N. Y. C. & H. R. R. R. Co., chairman.
A. Ames, Kerite Ins. Wire & Cable Co.
W. S. Clark, General Electrical Co.
A. L. Crater, N. Y., C. & H. R. R. R. Co.
R. W. Krass, New York Edison Co
W. I. Middleton, Simplex Wire & Cable Co.
F. J. White, Okonite Co.

Committee on Standardization of Train Lighting Lamps

At the June Convention your Committee presented a preliminary report on sizes of train lighting lamps which it was recommended that the Association adopt as standard. There was also included a list of train lighting lamps classified as "Accepted but not recommended." This covers lamps, with the exception of 75 watt lamp, which are used to so large an extent for train lighting purposes that it is improbable they will be replaced by standard lamps. The 75 watt 80 candle power G-30 lamp is a new train lighting lamp offered to meet the demands for a lamp larger than the 50 watt for use in enclosing units, indirect lighting, etc.

TABLE I.
LAMPS FOR RECOMMENDED PRACTICE

Voltage Range	Nominal Watts	Present Actual Watts	Mean Horizontal Candle Power	Efficiency In Watts Per Candle In Effect October 1	Type of Bulb
30 to 34	15	14.04	12	1.17	G-18-½
and	25	22.0	20	1.10	G-18-½
50 to 65	50	40.0	40	1.00	G-30
TRAIN LIGHTING LAMPS ACCEPTED BUT NOT RECOMMENDED					
30 to 34	15	14.04	12	1.17	S-17
and	25	22.0	20	1.10	S-19
60 to 65	75	76.0	80	.95	G-30

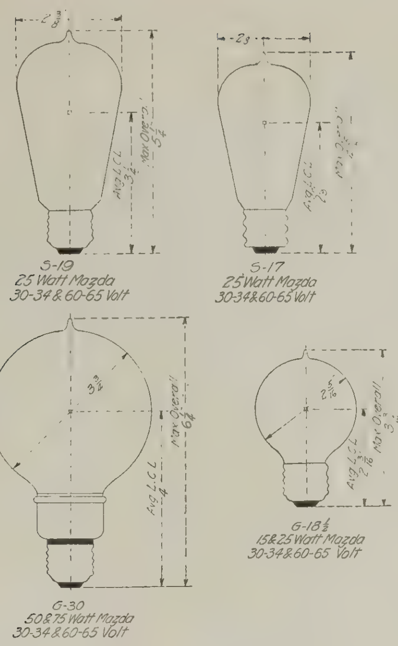


Fig. 1. Maximum Dimension of Standard Lamp Bulbs

Table I gives the engineering data for the lamps reported upon at the June Meeting, this data being based upon the efficiencies put into effect October 1st. Fig. 1 shows the maximum dimensions of the lamp bulbs and light center location of the lamps covered in this table.

Respectfully submitted,
L. S. Billau, B. & O. R. R.
C. W. Bender, Natl. Lamp Works of G. E. Co.

Committee on Yard Facilities for Charging Storage Batteries

It should be realized that it will be impossible to compile any report which can cover in detail all installations in each of which, differing local conditions are to be met. We will endeavor, however, to give an outline of what general facilities will be necessary.

In a previous report of the "Committee on Methods of Charging Storage Batteries" the multiple system with separate circuits from the charging switchboard to each outlet, and the constant potential system of yard wiring were described. We shall later, however, give an outline of a series system, which has been installed where the service is comparatively light and the climatic conditions severe.

The first consideration is the source of power, and in order to determine the size of generating units, the number of cars to be charged at one time must be known, the length of time they can be placed for charging, and the approximate amount of charging required. The answer to these questions will give the power demand. Presuming that this has been determined under normal conditions, it will be found that abnormal conditions caused by extremely cold weather interruptions to the service, etc., will at time cause a much greater demand, and we would, therefore, recommend an allowance of at least 50 per cent above the normal peak load. In order, however, to safeguard the service at all times, dependance should not be placed on a single unit plant, as in case of a breakdown the source of power will be entirely disrupted. In addition, the question of probable growth should be carefully considered, and the necessary allowance made.

When a small number of electrically lighted cars only are handled, small motor generators, single-phase converters or mercury arc rectifiers can be used, but we would not recommend the two latter unless some special conditions exist to make their use attractive.

Either 125-volt, two-wire, or 220-volt, three-wire, D. C. generators may be used for constant current multiple, or series multiple systems, but for the constant potential system two-wire generators only are suitable. Where 30-volt equipments are handled exclusively, a lower voltage may be considered. The main advantage of using the three-wire, 220-volt system, is the saving in copper made possible. If three-wire generators are used they should be constructed to stand a considerable load out of balance, as with the best of care exercised, both in the installation and operation, it has not been found possible to keep the lines balanced. This overbalance at times will reach between 40 per cent and 50 per cent of the total load.

Switchboard.

With the use of the constant potential and series systems a comparatively simple board will answer. If, however, the multiple system embracing a separate circuit to each outlet is used, an elaborate switchboard will be necessary, as each circuit should have switch, rheostat, and volt and ammeter connections.

Fig. 1 and Fig. 3 will show the comparative simplicity of a charging switchboard recently installed to control a yard of 254 outlets of the constant potential system, compared with that required to operate a yard of about 350 outlets with a separate circuit to each charging plug.

Yard Wiring.

When determining upon the size of conductors, the same conditions should be considered as when considering the size of the generating units, and in addition the length of circuits, charging rates and permissible drop should be considered. In order to economize in the amount of copper used, the layout should be designed to absorb as much of the voltage drop in the wiring as possible, but in no case should the individual circuits have a carrying capacity of less than 80 amperes.

While it is possible in some yards, where there is sufficient clearance between tracks for overhead construction, your committee is of the opinion that all wires should be installed underground, except as noted below, in vitrified duct laid on and surrounded by concrete, or fibre conduit installed in the same manner. The latter, we would recommend on account of its being cheaper than the former method, and giving equally as good results. In cold climates where there are excessive snow falls, it has been found that overhead construction is preferable as it is almost impossible to keep the outlets free from ice when located on the ground, and under such conditions we believe that this method will be the most satisfactory.

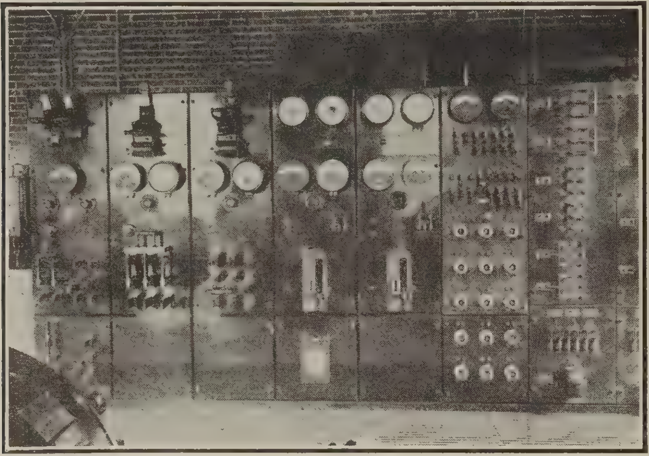


Fig. 1. Charging Switchboard for Yard of 254 Outlets Constant Potential System

When installing underground, rubber insulation of the best quality covered with tape and braid when properly installed, has been found to give excellent results. In several large constant potential installations recently constructed, the individual leads to the charging outlets were made up in duplex, rubber insulated, and armored by two wrappings of steel tape. These were laid underground without protection. There have been several failures with these cables, but we are unable at present to give the cause.

All manholes and outlet boxes should be as near waterproof as possible (we would recommend concrete construction throughout) and drained into a drainage system, unless the soil is sufficiently porous to carry off the moisture. The conduits should drain into the manholes each way from a slight hump of about three inches in the center, unless there is a sufficient grade to drain from one manhole to the next. Conduits should be plugged sufficiently to prevent the entrance of rats, (as in a number of cases of failures dead bodies of these rodents have been found at the faults) but not so tightly closed as to retain the water. Wires of opposite polarity should not be mixed in the same conduit. Unless the outlets are mounted on the sides of platforms, as a safety precaution, they should be under the surface in proper outlet boxes and the covers of these boxes together with the manhole covers should be as little above the surface as possible.

For overhead construction, bare copper wires should be satisfactory for the mains. Leads to the outlets to be rubber covered in conduit to the outlets.

Where only a small portion of the equipment is electrically lighted, it will not be necessary to equip the entire yard. In this case the transportation department should be taken into partnership, and a thorough understanding had with them relative to the necessity of placing cars for charging on the proper tracks. When a large portion or all of the cars are electrically lighted the entire yard should without a doubt be equipped. If the head-end or axle device systems are used a single line of outlets at about 150 ft. spacing will serve each pair of tracks. If, however, all

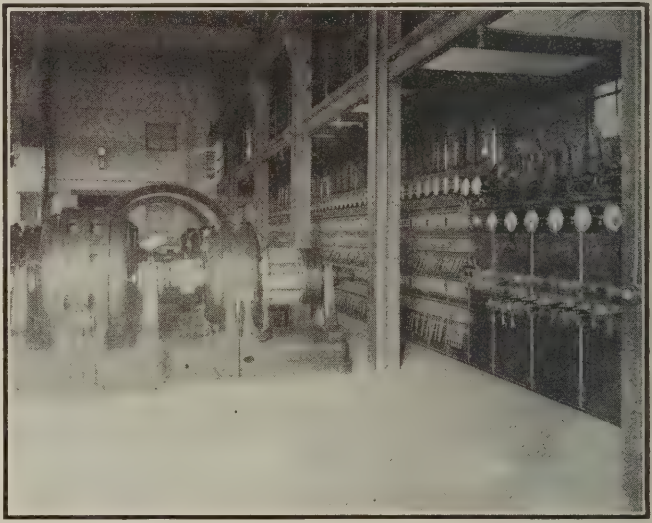


Fig. 3. Swtchboard for 350 Outlets With Separate Circuit to Each

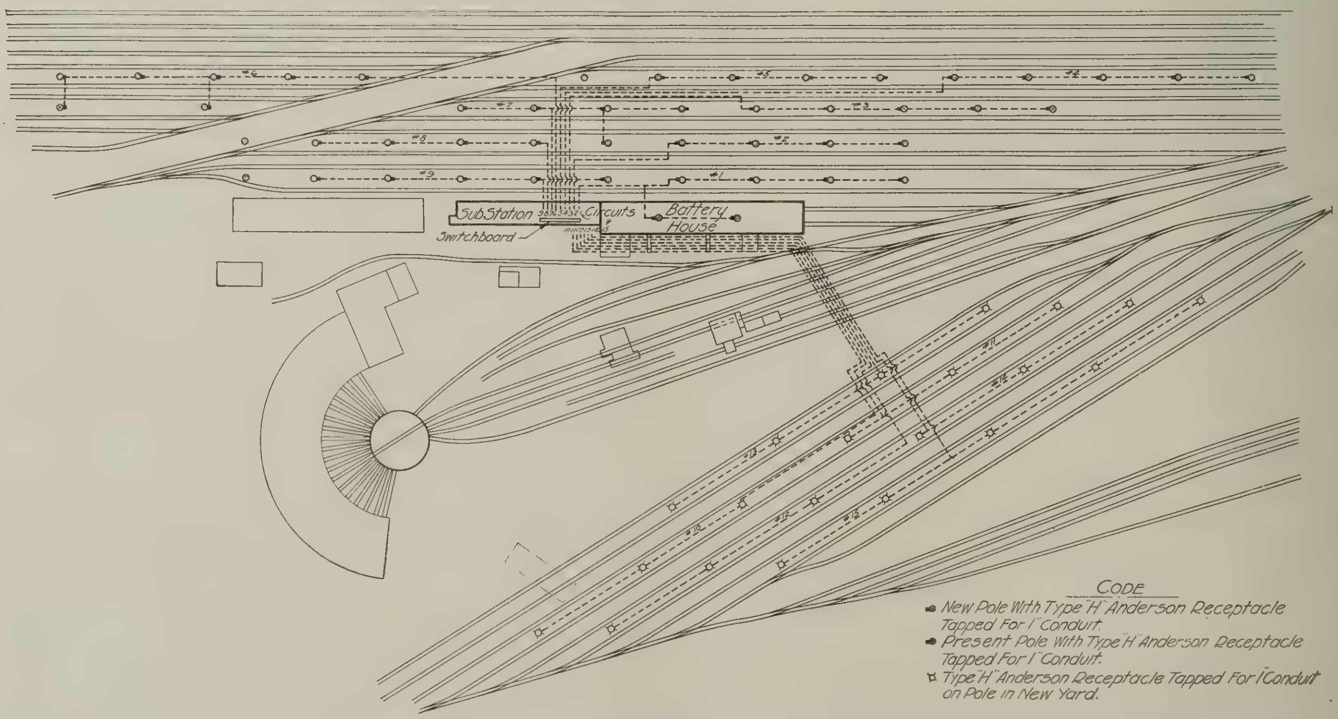

#6
#5
#4
#7
#3
#8
#2
#9
#1
SubStation
98765432 1
Circuits
10 11 12 13 14 15
Battery House
Switchboard
#10
#11
#12
#13
CODE
New Pole With Type "H" Anderson Receptacle Tapped For 1" Conduit.
Present Pole With Type "H" Anderson Receptacle Tapped For 1" Conduit.
Type "H" Anderson Receptacle Tapped For 1" Conduit on Pole in New Yard.

Fig. 2. Conduit System for Yard Charging

or a large portion of the cars are straight storage, the outlets should be placed at a car length apart, and if the yard is a busy one, it will be found of great advantage to have a line of plugs to serve each track.

Charging Cables.

Should be made up of two single No. 4 B. & S. extra flexible wires, with good rubber insulation, and pulled through a cheap quality of ⅞" rubber hose about 50 feet long. Cables, when made as suggested, are easier to handle and are more serviceable than when made of duplex wire. It will be impossible to say how many cables there should be in each case. Local conditions will entirely govern this.

Stock.

The foreman in charge of electric car lighting should at all times see that a sufficient stock for repairs and renewals are held, and he should also so regulate their use that the consumption be held at a minimum commensurate with good service, and that each item drawn from the storeroom be strictly accounted for.

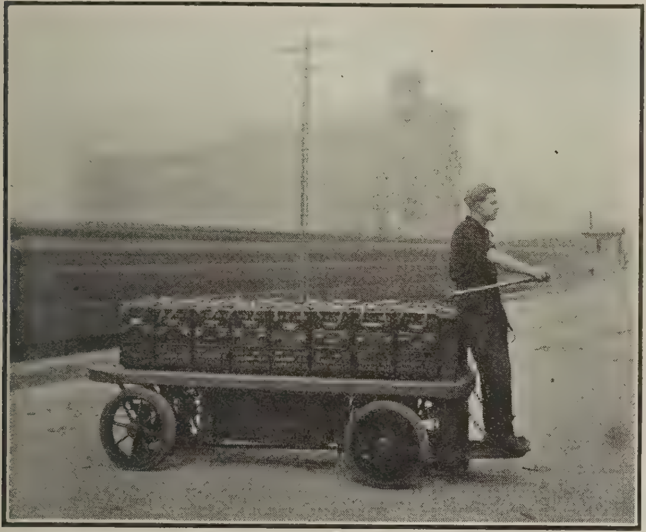


Fig. 4. Electrically Operated Battery Truck

Handling of Storage Batteries.

It is becoming more and more evident that platforms throughout a passenger yard are an economical investment. To the car lighting force they are a special blessing. An endless amount of drilling and continual delays can be saved if it is possible to make quick repairs and changes to the batteries and axle generators, and this cannot be accomplished without the use of trucks and platforms to operate them over. We would recommend concrete in place of wooden platforms, as the wooden ones are seldom kept in repair and the maintenance on power trucks is heavy when operating over uneven surfaces. We would recommend electrically operated trucks of sufficient capacity to carry a 30-volt set of standard car lighting batteries, and of a height to reduce the lifts both at the cars and battery racks to a minimum. Fig. 4 shows one of the newest and most convenient electrically operated trucks for use in handling storage batteries.

Battery Repairs.

It is the opinion of your Committee that it is the most convenient and economical plan to have the battery cleaning shops at the principal terminal yards. Against the policy of doing this work at the shops are the fact that there is no assurance even with the best of care exercised that the battery will last from one shopping of the car to the next, and also that the car will be handled through the yards before being placed in service. Before cars are shopped for class repairs, we believe the batteries, generator, and regulators should be removed and thoroughly repaired and inspected before being re-applied.

Battery Shop.

For convenience of operation it is desirable to have the office, battery cleaning and axle generator repair shops, lead burning room and switchboard controlling battery shop charging circuits in the same building, and located as near the center of the yard as possible, keeping in mind the following points:

(1) Convenience in moving batteries to and from cars.

(2) Convenience in reaching building with teams and freight cars.

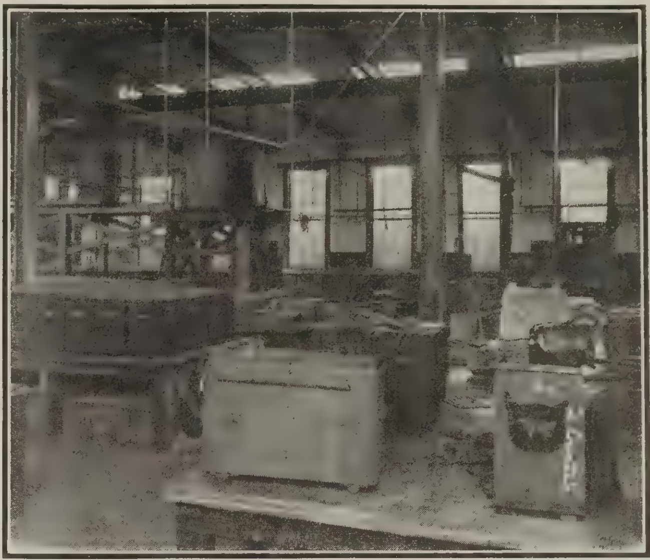


Fig. 5. Up-to-date Battery Shop

(3) Convenience to storeroom in all cases where supplies are not in the building.

The building should be well lighted and special care taken to properly ventilate both the battery shop and lead burning room.

In the battery shop the cleaning bench should be at right angles to the charging racks, and on each side should be sufficient room for the workers and battery trucks. The aisles between the charging racks need only be of sufficient width to load and unload the batteries from the trucks. The cleaning bench should be lead-covered and should drain through a series of traps, so that the battery sediment may be reclaimed and not drain into and stop up the sewage system. The leading burning room should be as near the cleaning bench as possible. Steam, running water, compressed air and distilled water should always be available. Among the appliances provided, should be pneumatic press for straightening the elements, tank for the electrolyte, steam caps for loosening the sealed in covers, water still and reservoir, electric heaters for heating petrolyte, and lead burning outfits. All the charging racks should be

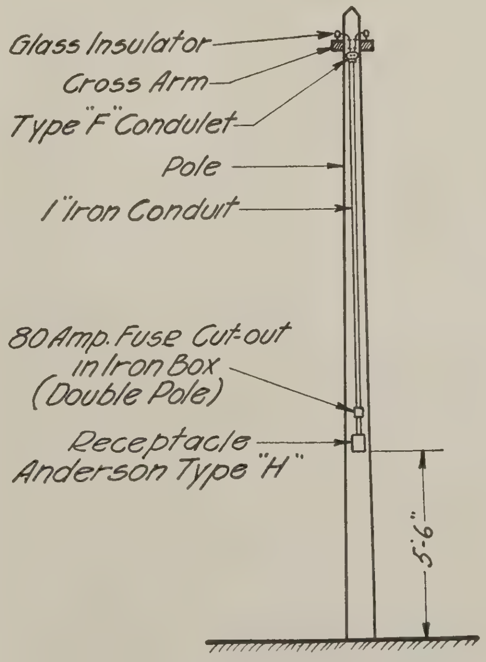

Glass Insulator
Cross Arm
Type "F" Condulet
Pole
1" Iron Conduit
80 Amp. Fuse Cut-out in Iron Box (Double Pole)
Receptacle Anderson Type "H"
5'-6"

Fig. 6. Yard Charging—Pole Distribution

fully equipped with charging circuits and the switchboard controlling these circuits so arranged that the batteries may be charged or discharged at will.

A strict account of all material used and its cost, together with all labor charges should be kept of each set of batteries handled.

The axle generator repair shop should be equipped with power-operated lathe, drill press, emery wheel, etc., also work bench with all necessary tools and small supplies as bolts, nuts, etc., available for immediate use. There should also be racks for testing the generators and regulators before they are placed in service. A traveling crane should be in both the battery and axle generator repair shops.

Fig. 5 shows an up-to-date battery shop at which about 60 full set of 60-volt car lighting batteries are cleaned and repaired each month, besides a number of truck batteries, etc. It has a storage capacity of about 65 sets of 60-volt train lighting batteries.

Fig. 7 shows the generating sets (2-100 and 1-75 K. W.) supplying switchboard on Fig. 1.

Fig. 9 shows the units (3-250 K. W.) supplying three-wire, 220-110 volt current for switchboard on Fig. 3.

The other illustrations show a series system installed overhead for charging 24-volt batteries. Power is supplied by 2-25 K. W. motor-generators. The generator panels are connected to seven distributing panels each equipped with reverse and overload circuit breaker, ammeter and grid resistance. On the receptacle panel the two rows of receptacles to the right are connected two in series to a circuit breaker. The two rows on the left are connected to the yard circuits. By means of short circuiting plugs and flexible connectors, cars on any two or three circuits in the yard can be charged in series:

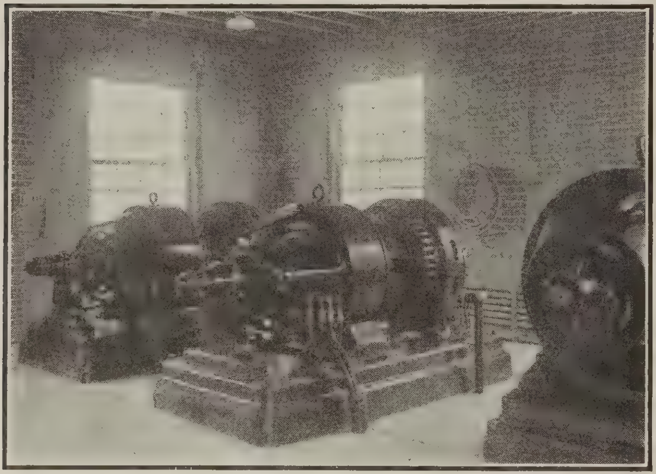


Fig. 7. Generating Sets Supplying Current for Switchboard in Fig. 1

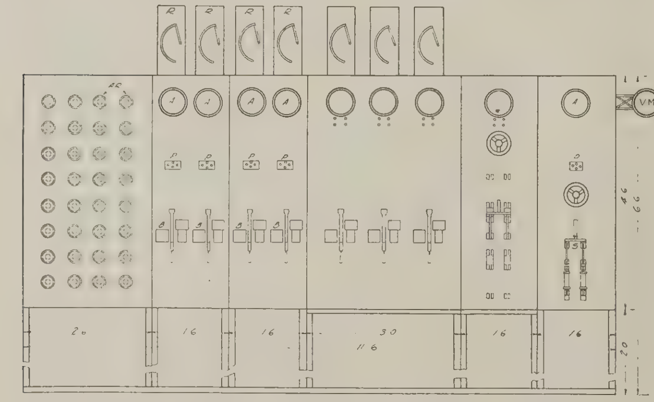


Fig. 8 Switchboard for Series Charging System

Cost of Installation of Series Wiring of Yard Charging Circuits.

GENERATOR, PANELS, ETC.		
2—25 K.W. motor generator sets		$2,500.00
5—Switchboard panels		975.00
WIRE.		
16,500 ft. No. 2 D. B. W. P. wire		594.00
2,600 ft. No. 2 D. B. R. C. cable		240.00
CHARGING RECEPTACLES.		
62—Charging receptacles		248.00
MISCELLANEOUS.		
1,250 ft. 1" conduit		125.00
62—1" condulets		70.00
Internal wiring battery house		100.00
70 poles (50% of total) valve		125.00
MISCELLANEOUS SUPPLIES.		..
Labor installing	600.00	$5,427.00
Overhead charges, 10% labor	60.00	
5% material	241.00	301.00
10% Eng. and contingencies		572.00
Total		$6,300.00

Note: As poles are also used for lighting of yard 50 per cent of cost only charged against the charging circuits.

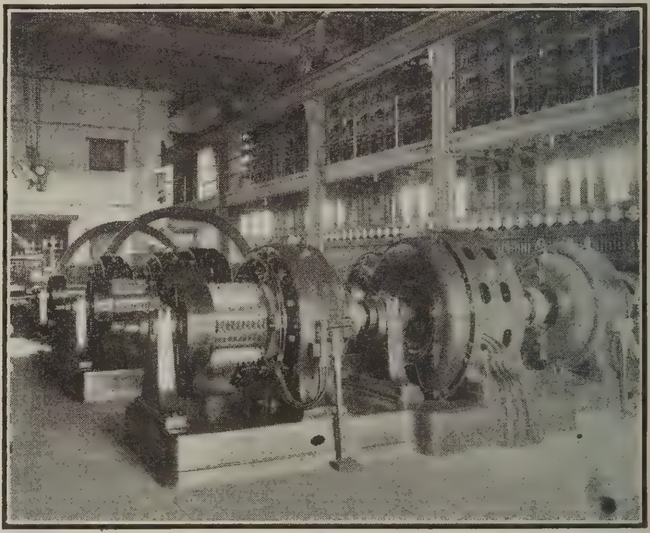


Fig. 9. Units Supplying 220 110 Volt Current for Switchboard, Shown in Fig. 3

We took the liberty of inviting Mr. W. C. Kershaw, foreman of electricians, Sunnyside yard, P. R. R., to attend a meeting of this committee in order to have the benefit of his large experience along the lines covered by this report.

Respectfully submitted,
D. B. PASTORIUS, Chairman.
N. H. KEIRN.
E. S. MACNAB.
J. A. ANDREUCETTI.

Polar Zone Electrification

The general adaptability of electricity is shown by the great number of ways in which it is used. With the Swedish electrification on the Kiruna-Riksgraensen Railroad, perhaps the first electric railway within the Artic circle will have been built. In this region snow is present during about three-quarters of the year, still it hauled in 1913 about 3,000,000 tons of iron ore. The object of the electrification was to eliminate smoke in tunnels and permit heavier trains and higher average speeds. The abundance of water power and scarcity of coal were also important factors in choosing electrification.

Single phase was adapted owing to the length of the line and the large amount of energy to be transmitted. The line will be of the simple catenary type with A-framed poles spaced 172 feet apart and the hangers spaced 58 feet. The customary double insulation has been replaced by single but larger insulators. To take care of temperature changes the catenary is free to glide along the cross piece within loops.

The locomotive equipment consists of two passenger locomotives (two pony axles, two drivers and two pony axles on one truck) and thirteen ore locomotives (one pony axle and three drivers each on two trucks).

The motors are of the series type with auxiliary excitation, each motor being supplied with a core transformer of the oil cooled type.

Committee on Electric Traction

This committee was appointed to review the present status of electric traction as applied to steam railroads and to present the principal features of and reasons for electrifications. It is the intention of the committee to present matters of general interest to railroad men without going into the technical details, which are the province of the consulting electrical engineer.

This report will be of a preliminary nature and further data, particularly as to operating costs, will be supplied in a subsequent report. The committee has been unfortunate in that one of its members who returned to Switzerland this year and who was to give us considerable data on the electric traction situation in Europe, has not been heard from.

The ordinary urban and interurban railway lines will not be discussed in this report, which is intended to apply only to the electrification of steam railroads or electric railways built to handle steam railroad class of traffic.

Description of Railroad Electrifications

The first electrical operation of railway equipment occurred on the Metropolitan Elevated of Chicago in 1895, and three years later the multiple unit system of trains was first operated on the South Side Elevated of Chicago. These roads were operated with 550-volt direct current by the use of a third rail, which had been used initially on the Intramural Railway at the World's Fair. A few years later the Boston Elevated Railway was built, using a similar system, and in 1902 the Manhattan Elevated Railway of New York changed from steam to electrical operation, using a similar third rail system and multiple unit trains.

Numerous small electric locomotives had been built for mining and industrial purposes, but the first electric locomotives for trunk line railway use were put in service in the Baltimore tunnel of the Baltimore & Ohio R. R. in 1895, and weighed 96 tons. Later several 160-ton two-unit locomotives were added to the electric equipment.

The western portion and a number of branches of the Long Island Railroad comprising 125 miles of single track were changed to 600-volt direct current electric operation in 1905. The electrification has been extended in recent years. Passenger traffic only is operated by multiple unit trains.

The following year the West Jersey & Seashore Railroad between Philadelphia and Atlantic City was electrified and operated multiple unit trains, using 600 volts direct current supplied by a third rail. This installation, covering 75 miles of double track, was noteworthy as being the first for long distance express service.

The Grand Central Terminal of the New York Central & Hudson River R. R. was changed to electric traction in 1906, and the electrification has gradually been extended from New York to White Plains on the Harlem Division, 22 miles, and to Harmon on the Hudson River Division, 33 miles, the system now comprising a total electrified single track mileage of approximately 165. There are sixty-three 115-ton locomotives now in service. The through trains are operated by electric locomotives interchanged with steam locomotives at the end of the electrified zone. The suburban traffic is handled with multiple unit trains. The third rail system of distribution is used, supplying direct current at 650 volts.

The New York, New Haven & Hartford was electrified in 1907 and originally extended from Woodlawn (between which point and New York it operates over the tracks of the New York Central) to Stamford, Conn., 21 miles. This electrification has since been extended to include the Harlem River Branch into New York and also from Stamford east to New Haven, aggregating about 160 miles of track. Through passenger and freight trains are hauled by electric locomotives. There are now about 100 locomotives of various classes, weighing from 80 to 140 tons each. There have been a number of locomotive designs to meet the conditions imposed by the traffic, such as gearless, geared, two motors per axle and side rod types. Part of the locomotives also contain equipment for operation by direct current third rail, in order to run over the New York Central. Some of the local passenger trains are operated by the multiple unit system. This electrification was the first large installation of alternating current traction, 11,000 volts at 25 cycles single phase being used. The distribution system consists of overhead catenary with both the double and single type of suspension. This installation was a pioneer of its type for heavy traction and many of the details had to go through certain experimentation and modification which has been the early experience with the practical application of all systems.

In 1906 the Spokane & Inland Empire R. R. was built for handling both freight and passenger business by electric traction. It was one of the most extensive systems then operated wholly by electricity. Locomotives and multiple unit trains are used with a 6,600-volt alternating current single phase system of distribution.

During 1907 electric traction was installed on the Rochester Division of the Erie Railroad for local traffic, using multiple unit trains. An alternating current system, similar to the New Haven electrification, was adopted with a single catenary supported on bracket construction. The power of this electrification was supplied by a sub-station at Avon from the Niagara Falls power circuits.

In 1908 the Grand Trunk Railway electrified the St. Clair tunnel, using 3,300 volts single phase alternating current with electric locomotives to handle main line trains through the tunnel.

The Cascade Tunnel of the Great Northern Railway was electrified in 1909 and all main line freight and passenger service was operated thereafter through the tunnel by 115-ton electric locomotives. This installation is interesting as being the first in America using three-phase alternating current with induction motors on the locomotives, and up to the present time it is the only system of this kind in this country.

The Oakland, Alameda & Berkeley Division of the Southern Pacific Railway; the Oneida Division of the West Shore R. R. in central New York; the Portland, Eugene & Eastern Ry., Oregon, and the Pacific Electric Ry. System centering at Los Angeles operate passenger and freight service over steam railroad lines, using the 600-1,200 volt direct current system with overhead catenary.

The Piedmont Traction Company operates 140 miles of line at Charlotte and Spartanburg, N. C., using the 1,500-volt direct current system. It handles local passenger and heavy freight service with multiple unit trains and 55-ton locomotives, hauling 800-ton trains. This line was completed in 1913.

The Washington, Baltimore & Anapolis R. R. was originally electrified in 1907, using a 6,600-volt single phase system. In 1910 the system was changed to 1,200-volt direct current. Passenger and freight traffic is handled over about 60 miles of line.

The Rock Island Southern Railway operates passenger and freight service between Monmouth and Rock Island, Ill., over about 60 miles of road. Locomotives and multiple unit cars are operated by single phase system using a 11,000-volt catenary.

The Fort Dodge, Des Moines and Southern R. R. operates about 126 miles of electrified lines between Fort Dodge and Des Moines, Ia. All traffic is handled by the high voltage direct current system.

The Denver & Interurban R. R. is an electrified branch of the Colorado & Southern Ry. and operates 44 miles at 11,000 volts single phase with multiple unit trains.

The Pennsylvania R. R. Terminal in New York, and the tunnel approaches were placed in operation in 1910, using the 700-volt direct current third rail system. This installation handles heavy passenger traffic only and the 156-ton locomotives are of the articulated type, using side rod drive. The Long Island R. R. also operates multiple unit trains into this Terminal.

The Hoosac Tunnel of the Boston & Maine R. R. is double track, five miles long, and the smoke conditions became so bad that the traffic could not be handled. Electric traction was adopted in 1911 and now all trains are hauled through by 130-ton electric locomotives, using the same single phase system as the New Haven.

The New York, Westchester & Boston Ry. was built for high speed electric passenger service and placed in operation during 1912. This road is 21 miles long, is part of the New Haven lines, and is operated by the same system, multiple unit trains being run.

Although direct current installations have been made at 1,200 to 1,500 volts, a higher voltage was not installed until 1913, when the Butte, Anaconda & Pacific Ry. was placed in operation, using 2,400 volts direct current. This road extends from Butte Hill to Anaconda, Mont., with branches, aggregating 37 miles, and is used principally for transportation of ore. Two 80-ton locomotives haul a 4,000-ton train on average level at 21 M. P. H. Passenger traffic is also handled by electric locomotives of the same weight but higher speed.

In Process of Electrification

At the present time there is in process of electrification a 30-mile division of the Norfolk & Western Ry. at Bluefield, W. Va. The principal traffic on this division is the transportation of coal and the necessity of increasing the transportation capacity of the single track Elkhorn Tunnel and obtaining more economical operation over heavy grades were the reasons for adopting electric traction. The electric locomotives have articulated trunks and weigh 130 tons. Four three-phase induction motors are installed on each locomotive, two on each truck geared to a jack shaft, which is connected to two driving axles by side rods. Two of these locomotives will haul 3,250-ton trains on light grades at 28 M. P. H. For 1% and heavier grades a speed of 14 M. P. H. can be obtained. A phase-splitting apparatus on the locomotive provides three-phase current for the motors. The distribution will be 11,000 volts single phase catenary supplied by outdoor transformer substations.

The Pennsylvania R. R. will electrify the Paoli Division out of Philadelphia this year to increase the capacity of the terminal and tracks. This division is 20 miles long and the electrification will apply only to the suburban passenger traffic at present. Multiple unit trains will be used and an 11,000-volt single phase alternating current system of distribution adopted, using the single overhead catenary.

A most interesting application of electric traction has recently been decided upon for a mountain division of the Chicago, Milwaukee & Puget Sound Ry. The total electrification contemplated is about 440 miles, extending from Harlowton, Montana, to Avery, Idaho; although only one division will be electrified at present, from Three Forks to Deer Lodge, 113 miles. The direct current system will be used at a potential of about 3,000 volts with catenary distribution. Two classes of locomotives will be provided to haul 800-ton passenger trains at 50 M. P. H. on level, and 2,500-ton freight trains over maximum mountain grades of 2%, respectively. This is practically the first instance of electrification being applied to a full division handling the regular trunk-line traffic.

The Canadian Northern Railway will electrify the new Montreal Terminal and tunnel through Mount Royal, together with a short suburban trackage, aggregating about ten miles of line. The 2,400-volt direct current system with catenary trolley will be used. The high voltage is adopted to provide a suitable distribution for future long-distance extensions of the suburban district. It is intended to use 83-ton locomotives with articulated trucks equipped with two motors per truck geared direct to driving axles. Multiple unit cars will be operated for suburban traffic. It is expected that this electrification will be completed during 1915.

There are a number of railroads, such as the Canadian Pacific Ry., Denver & Rio Grande R. R., Erie Railroad and others, which are considering electrification of certain sections, but their plans are not far enough advanced for reference at this time.

European Electrifications

Much experimental work has been done on the various lines electrified in Europe, sometimes resulting in peculiar designs and elaborate details.

In general the traffic is less and equipment is lighter than in the United States.

The better grade and lower cost of operating and maintenance labor used in Europe is favorable to the results obtained. The locomotives and distribution systems contain many refinements and are less rugged than usually considered necessary in this country.

Italy.

Italy has adopted the three-phase, 15 cycle, 3,000-volt system and good results are being obtained throughout. Valtellina, Giovi, Savona-Ceva and the Monza-Lecco are the principal lines electrified. The Valtellina line was electrified in 1902, comprises 65 miles of track, operates at 3,000 volts, 15 cycles, three-phase, and has 24 locomotives. The Giovi line comprises 28 miles of track, was electrified in 1910-13 and has 24 locomotives. The Savona-Ceva line was electrified in 1914, comprises 28 miles of single track, and is operated at 3,700 volts, 16 2-3 cycles, and has 24 locomotives. The Monza-Lecco line was electrified in 1914, using 3,400 volts, 15.8 cycles, and comprises 27 miles of track.

France.

The single phase, 15 cycle, 10,000-volt system is considered the standard system for trunk lines in France.

The principal electrifications are the Medi Railways and the Paris-Orleans Ry. The latter was electrified in 1898, eight 600-volt direct current locomotives being placed in service for the Paris end of this trunk line.

Switzerland.

The standard recommended by the Commission of Swiss Engineers was the single-phase, 15,000-volt, 15 cycle system.

There is a total of 319 K. M. of railways operated electrically and of this, 210 K. M. are operated by the single phase system.

Although the Simplon Tunnel and its approaches, comprising about 14 miles of track, has been in successful operation for the past 8 years and is showing good results with its three-phase system, it was not considered that this system was the best for general adoption for all Swiss roads.

The Loetschberg Tunnel is one of the most recent electrifications using the single phase system.

Germany.

The trunk lines in Germany are practically all owned and operated by the state governments. The Prussia system is the largest and represents the general conditions prevailing in other states.

The system recommended in a report to the Prussian Government some years ago and the one adopted is the single phase, 10,000-volt, 15 cycle system. This voltage is to be increased to about 15,000 volts if operation at a lower voltage proves entirely satisfactory. This increase in voltage has already been made on the Dessau-Bitterfeld road.

The locomotives on this system are equipped with large motors mounted on the cab floor, and connected to the drivers with inclined side rods, either direct or through a jack shaft. Experimental work is being carried on with the geared type as considerable difficulty has been experienced with mechanical parts of the side rod locomotive.

Electric Traction System

Since the first trolley line installation in Richmond, Va., in 1888, which was low voltage, direct current, there has been a gradual evolution in traction systems based on the requirements for heavier and more extended service. On the one hand this has led to increasing the voltage of the direct current system and on the other hand the system of alternating current traction has been developed in order to utilize the possibilities of high voltage distribution without limit.

At the present time electric traction systems may be divided in the general classifications of direct current and alternating current, each class having several methods of application varying more or less in fundamental details.

Classification of Systems.

Direct Current.

1. Low voltage; 600-750.
2. High Voltage; 1,200-2,400-3,000.

Alternating Current.

3. Single Phase with commutating motors.
4. Three Phase with induction motors.
5. Single Phase with induction motors (Split Phase).

6. Direct current rectified from alternating current.

A brief review of the salient features of the systems will now be given for reference.

Direct Current—Low Voltage.

This is the original and commonest form of electric traction in this country and applies particularly to trolley service both urban and interurban. It has been used extensively for short railroad electrifications, principally for terminal installations.

Details of construction and operation have been thoroughly worked out and very satisfactory results have been obtained.

The system is extremely flexible and is particularly desirable for its range of operating speed; but it cannot be considered economical for long lines carrying heavy traffic, as expensive substation installations are required in such cases and the distribution system will be unduly expensive. The potential used for these installations varies from 500 to 750 volts, and for traction work a third-rail system of distribution is almost universal, as it is not practicable to collect the heavy currents taken by the locomotives from a trolley wire.

Direct Current—High Voltage.

It has been a natural step in the progress of electric traction to increase the voltage and thus reduce the amount of current to be transmitted for a given load requirement. First the potential was doubled and 1,200 volts has been used for a number of interurban electric railway installations. This voltage has not been used on any trunk line steam railway electrification, probably due to the fact that no such electrifications were decided upon during this period, because it shortly became evident that it would be practicable to use a still higher voltage. Therefore 2,400 and 3,000 volts is now considered standard for high voltage direct current heavy traction installation. It might be explained that this high voltage use of direct current for railway motors has been made possible by the development of the commutating pole (interpole) type of motors and the better insulation design which has been developed in the last few years. The railway motors are usually arranged to operate two in series thus giving 1,200-1,500 volts.

The method of control for the motor equipment is usually the series parallel rheostatic type similar to that which has become standard for low voltage traction and embodies the various details of electrically operated or pneumatically operated contractors arranged for multiple unit operation of two or more groups of equipment.

There has been some experimental work carried on in Europe with this high voltage direct current for traction purposes even in excess of 3,000 volts, but it is safe to say that this country is probably the leader in the practical application of this system at the present time.

It is doubtful if a third-rail system of distribution will be desirable for this high voltage direct current, due to the necessity for considerable insulation coupled with the requirement of obtaining sufficient clearness for the installation. It will be interesting to observe the experience of the Michigan United Traction Co., which proposes to install a 2,400-volt third-rail system. The Butte, Anaconda & Pacific Railway is the only railroad actually in service using 2400-volt direct current traction, although there are a number of other installations now in process of construction or contemplated.

The distribution of high voltage direct current is usually obtained from substations containing rotary converters or motor generator sets, which are supplied through transformers from a high tension alternating current transmission line. The converters or generators are of the interpole type, built to deliver 1,200-1,500 volts direct from one machine, and two of these machines are connected in series to obtain the high voltage.

The direct current systems have the advantage of a wide range of running speeds, and the tractive effort characteristic of direct current motors is also very desirable, as it gives very high values at low speeds and starting, and relatively low tractive effort at the higher running speeds.

A. C. Single Phase With Commutating Motors.

This is known as the single phase system, and has been used on a number of installations in America, and is quite generally used in Europe. The principal installation in this country is that of the New York, New Haven & Hartford R. R., which is operated at '11,000 volts 25 cycles.

The attractive feature of this system has been its ability to supply distribution direct to the locomotive at high voltage, the only limitation being the practicable insulation of the locomotive equipment. It has not been found necessary to go beyond 12,000 volts up to the present time, and this potential provides for heavy power supply with 20 to 30 miles between generating stations or transformer sub-stations if the power is taken from a transmission system.

It has been the standard practice in America to use 25 cycles for this system as a higher frequency is not practicable. Most of the European installations have been at 15 cycles, which is preferable from an engineering standpoint, but has not been looked upon with favor in this country as it requires the development of new apparatus and isolates the power system from the usual commercial power developments.

The advantages of this system consist in the elimination of sub-stations with rotating apparatus—an extensive electrification only requiring outdoor sub-stations containing transformers and switching equipment—and the smaller amount of copper for feeder requirements.

The single phase commutating type of motor cannot be considered entirely satisfactory, and the weight and first cost of this motor compared with direct current or induction motors is a disadvantage which apparently cannot be overcome.

As an auto transformer is used to supply the reduced voltage to the motors, the starting and speed control of the motor equipment is extremely simple, being obtained by any desired number of taps on the auto transformer. This provides a flexible operating condition and results in extremely smooth accelleration.

A. C. Three Phase With Induction Motors.

The three phase system of distribution operating induction motor equipment on locomotives has been used considerably in Europe and is standard for the principal railways in Italy. A double trolley and track circuit is used for the three legs of the system. This system also allows a high voltage distribution similar to the single phase, except the proximity of the two trolleys necessarily place a more definite limit on voltage.

The ony installation of this kind in this country is through the Cascade Tunnel of the Great Northern Railway, and has been in successful operation for about five years.

The double trolley construction has always been considered difficult and impracticable in America and is not looked upon favorably for extensive railway work, due to its high cost and difficult maintenance.

The induction motors have to run at a constant speed irrespective of the load, but in order to obtain a certain amount of flexibility it has usually been the case that two speeds are provided either by operating motors in Cascade, or by changing pole connections. This speed limitation might be a serious disadvantage for suburban traffic, where trains make frequent stops or run under close headway, but for trunk line operation it would not appear to be detrimental, in fact it can be readily seen that there might be an advantage in operating trains over a division at a constant speed irrespective of train weight or grade.

The control of the induction motors is usually by means of resistance in the secondary circuit, and this gives very satisfactory results as regards smooth accellertaion. Of course the absence of a commutator in the induction motor is an important advantage, and in general an induction motor is one of the most rugged types constructed and requires a minimum of maintenance.

It is doubtful if this three phase system of distribution will be used in the future, as the induction motor equipment can be supplied from a single phase system as pointed out in the following paragraph.

A. C. Single Phase With Induction Motors (Split Phase).

In order to get the benefit of induction motor equipment on locomotives and obviate the necessity of using a double trolley distribution, there has recently been developed a rotating piece of apparatus designated a phase-converter, which is a special form of induction motor located on the locomotive, and so arranged as to receive single phase alternating current from the line and provide three phase current for the motors. This combination has been designated the "split phase" system, and includes all the operating features of the three phase induction motor equipment, referred to previously, supplied from a single phase trolley.

An important installation of this system is now being made on the Norfolk & Western Railway.

Direct Current Rectified From Alternating Current.

Experimental work has been carried on for some time with a system using the high voltage single phase distribution supplying alternating current to the locomotive or car containing transformer and a form of mercury arc rectifier, which in tun furnishes direct current at any voltage desired for the standard type of series motors.

Progress along this line is still in the experimental stage, so that none of the large manufacturers are yet ready to propose the use of this system for steam railroad electrification. However, it has very attractive features, and assuming that the details can be satisfactorily worked out, it would seem to be ideal for many installations.

Single Phase Distribution.

It is apparent that the alternating current single phase distribution has certain advantages of high voltage and minimum substation and copper requirements which are distinctive. Furthermore this form of distribution remains the same to supply single phase commutating motor, equipment, induction motor equipment, or (assuming its ultimate development) the standard direct current series motor through the medium of the mercury arc rectifier.

One of the serious operating difficulties which has been experienced with the single phase system of distribution is the interference caused by induction in other nearby parallel lines, such as telephone and telegraph wires. At times this has assumed a very serious aspect and considerable experimentation has been carried on to protect against such interference. This induction is caused by the fact that the trolley, constituting one leg of the single phase circuit, and the track the other are so far apart that the inductive fields set up extend to a considerable distance, thus affecting any lines within their scope.

It is claimed that there has now been developed a satisfactory system of counter induction which can be installed so as to eliminate the serious effect of this interference from the single phase distribution, and this is being tried out in actual practice on some of the branches of the New Haven system.

Electric Braking.

In the case of electrification of railroads having heavy grades, such as occur on Mountain Divisions, the use of dynamic braking is an important consideration, as it saves wear and tear on the mechanical braking equipment and adds to the safety of operation. The three-phase induction motor equipment is particularly applicable to dynamic braking, and control and operation is relatively simple. With this equipment the speed is automatically limited as long as the motors are connected to the line, because they cannot be speeded up but a slight amount above synchronism.

The direct current system can also be adapted to dynamic braking, although it is only fair to point out that this entails more complication with the control and does not furnish as positive a speed limit as the induction motor equipment.

In either case it is essential that the contract be maintained between the locomotive and the distribution system, and in a small installation it is advisable to provide a resistance load on the distribution system to consume the power generated by the dynamic braking.

Choice of System.

In conclusion it can be stated that the economics of a particular proposed electrification can be studied and decided on broad grounds irrespective of system as the first cost and operating expense for an alternating or direct current installation will not usually be enough different to affect the result. The selection of system will depend on extent of electrification, character of traffic and local conditions, and will be principally an engineering determination.

Electrification for Terminal Improvement

Consideration of Smoke.

The electrification of steam railroads at terminals is frequently necessitated to satisfy the public. Laws are sometimes passed enforcing the elimination of the smoke nuisances, and these result naturally in electrification. Since terminals are usually located in or near the most congested portions of the cities they serve, the approaches necessarily pass through residential districts and therefore the presence of smoke is a source of much criticism and objection on the part of the public. On this account the elimintaion of such a nuisance is considered, even where action is not forced by law.

Financial Consideration.

Terminal electrification is not as a rule decided upon for economical purposes. The reason for this is that the economies that actually do result from cheaper operating expenses and maintenance are swallowed up in paying the interest on the large investment required. This covers not only the cost of electrification itself, but also other improvements which are usually carried on at the same time, such as new stations, elevation of tracks, tunnels or cuts, etc. Another consideration that prevents economies from resulting is the fact that electrification of terminals does not eliminate or replace old equipment, but adds to it. This is because the territory covered by the improvement is over only a small area and the distance affected too short to bring about any reduction in the amount of steam equipment needed. If it were possible for the first electrification to be extended over one locomotive division, the resulting economies would be a determining factor to a much larger degree than has been the case in the past when only a few miles outside of the terminal has been electrified.

Tunnels.

When terminals are reached by tunnels, the change from steam to electricity is almost a necessity regardless of economical consideration, on account of the danger of operation and the difficulty of maintaining a fast or frequent schedule due to the smoke. However, even where there are no tunnels, it is often found that electricity solves the problem, when the limit in space of a congested terminal or in the available trackage leading to it is reached. In cases of this sort, it is impossible to get the desired number of trains in and out over the given number of tracks, without considering electrification; the alternative for this condition lies in increasing track facilities by widening the right of way, or by providing tracks on two lines.

Relieving Congestion.

In congested city districts this plan is impracticable either because of lack of available space for extensions or prohibitive expense of obtaining additional space. The only way left is to increase the effectiveness of the existing terminals and trackage and the use of electricity as a motive power accomplishes this.

Electrification makes possible the operation of a larger number of trains over the same tracks with the same degree of safety. Acceleration is faster and the absence of smoke makes it possible to run trains under a closer headway than with steam locomotives. Also many light engine moves are eliminated because there is no need for electric engines to make a trip for coal or water, or to the ash pit.

The ability to get more service out of a fixed number of tracks by means of electrification affects what was said above in connection with questions of economy. This is one case where even terminal electrification over a short distance might be an economical proposition, if the investment required for changing from steam to electricity is less than or even about the same as what would be needed for larger terminal facilities and increased trackage. If the investment were about the same, the consequent savings of electric operations and the advantages accruing from public satisfaction and advertising value would throw the balance in the favor of electrification.

Electrification for Suburban Traffic

Steam railroads having a considerable suburban traffic afford a very attractive opportunity for electrification. This kind of service operated by means of steam locomotives is by no means an economical proposition, and it is not practical to give a very frequent schedule over a large part of the day and the stopping places are necessarily a long distance apart. On account of these facts, trolley lines that parallel railroads form a very serious element in the way of competition. The trolly gives a frequent service, making many stops, and with its branches reaching a number of outlying points not touched by the steam line. Electrification of the steam road makes possible a rather close approximation to the advantages of the trolley, and therefore brings the competition on a more nearly equal basis. This is especially a case where the competing company operates one of the many high speed interurban trolley lines using multiple unit cars. Under such circumstances the steam road by electrifying the already existing tracks can practically duplicate the service of the parallel road. The through service can still be handled by steam engines until such time as it is advantageous to make a complete change to electric operation.

Increase of Traffic.

In this way, also the traffic of a suburban road may be increased, for the improved service, with its large number of trains and its faster schedule, is bound to bring about this result. On branch lines where steam operation would be eliminated, there would be greater inducements for building up new sections on account of the absence of smoke and this would naturally lead to an increase in traffic.

The schedule of trains serving a suburban district can be greatly improved by electric operation. This is brought about by the quicker acceleration and as a rule the quicker braking that is possible. All this results from the use of multiple unit trains, where each car has its own motors, and the motive power available is thereby proportioned to the number of cars in the train. Also there is not the additional weight of a locomotive to be started and stopped, and therefore the entire weight of the train is made up of cars all of which are effective for the carrying of passengers. The same reasons explain why it is safe to maintain not only a faster schedule, but also a closer schedule, which allows a larger number of trains to be operated over a given number of tracks than would be practicable with steam.

The advertising value of the change from steam to electricity is considerable, as it is in reality satisfying public needs, or at any rate public desires. What the public wants very much, soon comes to be a necessity, and there is no doubt that more and more it is true that the public wants the electrification of steam railroads, especially on their suburban branches.

Electrification of Tunnels

Next to the electrification of terminals, the principal field of application for electric traction has been the operation through tunnels. There have been many cases of existing steam railroad tunnels where the conditions of operation were almost impossible, due to excessive heat, smoke and steam. Heavy grades are a usual accompaniment of tunnels and further complicate the ventilation difficulties with steam operation.

The following example of steam operation is interesting. The Cascade tunnel of the Great Northern Ry., situated about 100 miles east of Seattle, Wash., is something over two miles long with a constant grade of 1.7%. The difficulties of operating this tunnel by steam against the grade were enormous. On arriving at the tunnel locomotive fires would be drawn and new fires built with a special coal. An hour or more would be spent coking these fires and getting them into shape to make the run through the tunnel. The train would then be cut in two unequal parts, the lighter part being first taken through by a helper engine stationed regularly at the tunnel and the heavier part by the two road engines, one pulling and one pushing. The temperature of the air in the cab of the second engine was almost unbearable, sometimes going as high as 200 deg. F. Often it was impossible to maintain steam in the rear engine on account of the vitiated condition of the air, and the train would have to be cut in two and the rear part run out, down the grade. After one train had gone through it would be twenty minutes to an hour, before another could enter. In the event of a change in the wind the gases would pocket in the tunnel and sometimes it would be three hours before it was safe to start another train through.

These difficulties have been overcome by operating trains electrically, either interchanging steam and electric locomotives or hauling the complete train with its steam locomotive dead. In other cases, tunnel construction has been used where electrification was part of the operating plan at the outset. In fact it is recognized that many such cases would not be an operating possibility without electric traction, for instance the river tunnels entering the Pennsylvania Terminal in New York.

Aside from the importance of this feature there have been a number of instances where a single track tunnel constituted the capacity limitation of a railroad line. The well known facility of increasing traffic movement by higher schedule speed especially on grades and by hauling heavier trains with electric traction has made it possible to accomplish the desired end without recourse to double tracking a tunnel section. This is the main reason for the electrification of the Norfolk & Western Railway.

The greater number of tunnels which have been changed from steam to electric operation have been decided upon for the purpose of increasing safety of operation, both as to visability of signals and lessening the discomfort of heat and danger of gas asphyxiation. The Cascade, St. Clair, Hoosac, Detroit River and Grand Central tunnels are striking examples of this condition. The double track Hoosac Tunnel handled double the traffic after electrification.

Electrification of Mountain Divisions

A number of railroads have considered the electrification of certain mountain districts—where numerous and heavy grades predominated. There are several reasons favoring electric traction for such divisions.

First: The heavy grades impose a slow schedule for steam operation and either the large Mallet locomotives must be used for freight traffic or the maximum train weight kept below 1,200 tons. The electric locomotive can supply an excess tractive effort for moderate length grades and thus maintain speed. By using two or three electric units operated as one, the equivalent power of the largest Mallet is obtained but the crew cost and maintenance expense will be in favor of the electric. It is entirely practicable to handle 2,000 to 4,000 ton trains with the electrics.

Second: Usually the mountain divisions will contain grades of 22% or more which are operated as helper districts. The cost per mile for this steam helper service is usually excessive. Even if electric helpers are required, the flexibility of operation and better speed obtainable will make it possible to reduce the cost of this service.

Third: Tunnels are a common accompaniment of mountain lines and it has been pointed out how safety and economy favor the electrification of same.

Fourth: Mountain districts, by the nature of the country, usually contain water power sites which can be used for hydro-electric power supply, thus making it possible to obtain operating power at relatively low cost.

Fifth: The forest tracts traversed are subject to fires started from steam locomotives. This condition is so serious on some roads that an extensive fire patrol and fighting force has to be kept in service. This expense and fire damage would be saved by electric operation.

Sixth: Electric traction makes dynamic braking possible, thereby increasing safety and saving wear and repairs on brake equipment.

The Chicago, Milwaukee & Puget Sound; Butte, Anaconda & Pacific, and the Norfolk & Western electrifications are the best examples under this classification.

Electrification of Single Track Roads

It is a demonstrable fact that more traffic can be handled electrically than by steam on account of facility of train movement and ability to maintain a higher schedule speed without increasing the maximum speed.

It can be shown, in the case of a single track road operating at full capacity, that electrification will enable it to handle additional traffic, thus postponing double tracking. The fixed charges saved on the cost of double tracking for this period may properly be credited to the electrification annual expense in calculating the economics.

Electrification of Passenger and Freight Yards

Some of the terminal electrifications around New York have necessitated the extension of the system to large yards. The Sunnyside Yard of the Pennsylvania, containing 37 miles of track and covering 153 acres, and the Mott Haven Yard of the New York Central having 15 miles of electrified track, take care of the passenger equipment for their respective terminals. All switching in these yards is done with electric locomotives supplied from 600 volt third rail.

The New Haven system has electrified all its terminus freight yards on the Harlem River Branch. The 11,000 volt overhead catenary is installed throughout, the single messenger cables being supported from cross catenary spans covering a number of tracks between poles. The Harlem River Yard comprises 21 miles of track and the Westchester Yard about 15 miles of track. The main classification yard at Oak Point has a trackage of 36 miles. The movements in these yards are handled by special electric switcher locomotives weighing 80 tons.

There has been some controversy with the labor unions regarding the danger to trainmen from the overhead catenary in these yards, but they have been operated successfully for over a year now under a strict rule forbidding trainmen to work on top of the cars.

The several yard electrifications referred to above are the best examples in this country.

In this connection it might be mentioned that the comprehensive railroad terminal and yard improvements now being considered for the City of Chicago are meeting with serious objections on the part of organized labor against any form of electrification using third-rail or overhead trolley. There is no justification for this extreme view and operating experience with electrifications will not sustain it.

Power Supply

The supply of power for railroad electrification will usually be obtained by (a) purchase from a power company, (b) steam plant, or (c) hydro-electric plant, built and operated by the railroad.

It is the tendency for power companies to operate an extensive system of transmission supplied by several generating stations. There are many locations in the United States where such systems are in operation. A large power system will usually have a good diversity factor and can afford to make very favorable rates. The several generating stations and different feeding in points of the transmission increases the reliability of service. Therefore, where a suitable power supply is available it will usually be cheaper and more reliable for the railroad to purchase its power for electrification rather than generate it. This will also relieve it of a large initial investment and the necessity of organizing and operating an entirely separate department.

Contracts for hydro-electric power have been made on a basis of $20 to $30 per horse power per year. One electrification purchases power for .5 cents per K. W. H. Usually these power contracts provide for minimum and maximum demands and the rate depends on power factor and equivalent load factor.

The Erie R. R.; Great Northern Ry.; Butte, Anaconda & Pacific; Michigan Central (Detroit Tunnel); St. Paul and some others purchase all power for electric traction.

If a railroad supplies its own power for electrification from a steam station and has no other load, it will operate at a low load factor, unless a dense and uniform traffic is handled, resulting in a large installation for a low average load. This means poor economy. A large steam turbine plant, favorably located outside of a city, with coal at $2.25 per ton and a load factor of 45% can make power for about .7 cent per K. W. H., including fixed charges.

A hydro-electric plant will usually require a larger investment and unless there is more than one plant, with ample water supply, a steam standby station is almost a necessity; thus again putting a burden on the cost of power.

The economics of power supply for an electrification is of the utmost importance and the particular situation under consideration should be carefully analyzed by a competent engineer familiar with power generation and costs.

Construction Cost and Annual Expense

The construction cost of an electrification including power plant will not be affected greatly by the system adopted but the character and extent of the installation will have the greatest influence. For instance, in a concrete case that has been analyzed the total cost of electrification for a 145 mile division was about six times the cost of electrifying a 12 mile section in the same division for the same passing traffic. This comes about because of the relatively higher cost of power plant for the short section, and the better mileage obtained from locomotives having a division run, thus requiring a proportionately smaller number.

The operating costs will likewise be in favor of the extensive installations even in a greater proportion than the first cost. The fixed charges, of course, will bear the same relation as the construction cost.

The overhead catenary cost per mile is usually less than third rail. Similar construction is used for high voltage direct current and single phase catenary, the amount of insulation being the principal difference.

The direct current systems will require substations containing rotative apparatus and the construction cost and operating expense will be considerably more than for the outdoor transformer substations with the alternating system. If 60 cycle power is purchased for an alternating current electrification it will be necessary to use substations with frequency changer sets in order to supply 25 cycle power.

Locomotive Maintenance

The cost of locomotive maintenance and repairs per mile operated is without doubt in favor of the electric unit as compared with the steam. There are two reasons why this result is obtained; first, the absence of boiler, fire box, and reciprocating equipment in the electric locomotives materially reduces the repairs; second, the greater mileage obtainable with electric locomotives results in a lower traffic average cost.

Depending upon the character of the traffic and the operating conditions under which the locomotives are used, the cost of maintenance for electric units usually varies from 4 to 8 cents per locomotive mile. Some of the Baltimore & Ohio R. R. tunnel electric locomotives have shown an annual maintenance cost as low as 3 cents per locomotive mile. This must be considered an unusually good result and is probably obtainable because of the character of the service and the great annual mileage, which averaged over 350 per day.

The Pennsylvania, New York Central and New Haven locomotives have been operated at a maintenance cost ranging from 4½ to 6½ cents per locomotive mile.

The cost of steam locomotive maintenance varies very widely and it is not safe to make general comparisons. However, reliable data has been obtained on one large railroad electrification which indicates that with electric and steam locomotives handling the same character of traffic and operating under similar conditions, the cost of maintenance and repairs per locomotive mile is just about one-half as much, for the electric as for the steam locomotives.

Economics of Electric Traction

Various reasons for the electrification of portions of steam railroad have been given and in many cases the necessities of the situation governed the decision. As an alternative to double-tracking, tunnel enlargement, grade reductions, increase in terminal space, or other large expenditures required either by traffic conditions or legislative enactment, electrification will usually show an economic saving. That is, the recognized decrease in maintenance and repair cost of electric locomotive equipment, saving in crew wages, and reduction in cost of power will more than counterbalance the additional operating cost of electric transmission and distributing systems. In these cases the first cost of electrification is offset by the saving in not making the other improvement. In this connection it should be borne in mind that the first cost of electric locomotives—which will amount to about one-third of the total cost of an electrification including power plant—should not be treated wholly as an electrification investment, because they can usually be considered as a normal addition to the motive power equipment of the road. In any case there should be credited against the cost of the locomotives the cost of equivalent steam locomotives which do the same work, assuming that the railroad is large enough to absorb the steam locomotives displaced.

The cost of handling freight trains can usually be reduced by the higher schedule speed obtainable due to the overload characteristics and high tractive effort at low speeds of electric locomotives on grades, and the larger train units which can be operated, thus reducing the number of trains for a given traffic. It is also a fact that electric locomotives can make from 50% to 100% more mileage per year than steam locomotives due to facility of operation, less round house time and fewer major repairs.

Railroad electrification for straight economy over steam operation, where there are no contingent improvements saved which can be credited to cost of electrification, will not usually show sufficient net saving in expenses to provide for interest on the investment and amortization. Of course all conditions must be taken into account and a detailed study made in any particular case to arrive at a final answer as to the economies. For instance, as a power plant represents about one-third the cost of an electrification, the purchase of power may affect the result and an unusually cheap power supply, such as may be obtained from hydro-electric developments in certain localities, will often make electrification prove economical.

Generally speaking, the savings in operation due to electrification of a steam railroad result from two principal causes; first, that due to reduction in fuel consumption, locomotive maintenance and repairs, engine house expenses and other detail costs; and second, that due to reduction in number of freight trains to handle a given traffic.

The reduction in the amount of coal hauled for locomotive purposes, where a steam plant is substituted, would materially affect the traffic operation. This hauling of coal would be entirely eliminated where power was purchased or generated in hydro-electro plants.

Electric operation of passenger trains provides cleaner and faster service which is attractive to the public and results in greater traffic, increasing the gross earnings.

Respectfully submitted,

Committee on Electric Traction,
H. M. VanGelder, Chairman.
J. H. Davis.
D. C. Woodbury.
Paul Real.
Charles P. Kahler.
C. B. Keiser.

A. B. C. Car Lighting Course

Edited by Edward Wray

Lesson No. 33

Brown Boveri (German) System

The Brown Boveri system, which has been more or less extensively used in Germany and Austria, is far different from most car lighting systems and has some points of interest. The generator is of an ordinary two pole variable speed type, in which regulation is effected by automatically varying the resistance in series with the generator shunt field.

Automatic Switch.

The automatic switch of this equipment is very unique. The winding of the switch magnet constitutes the first step of resistance in the generator field circuit. It therefore depends upon the operation of the regulator itself.

Regulator.

The regulator is of a very unique design, although similar in principle to that of the type "L" Consolidated, with a curved shoe rocking over segments connected to sections of generator field resistance. Upon referring to the wiring diagram, Fig. 176, the generator field resistance is shown at G and the rocking contact shoe, R. The main solenoid of the regulator consists of three windings, I, which is a shunt winding of fine wire; II, a few turns of series coil through which battery current flows, and III, many turns of a heavy series coil through which the lamp current flows. Coils I and II are wound so that their magnetism acts together, but coil III is wound so that its magnetism opposes that of coils I and II. This compound solenoid creates magnetism in a vertical direction.

There is an additional coil O made up of many turns of fine wire connected in series with I, and this is pivoted so that it can turn through an angle of about 45 deg., as shown in the diagram. Current passing through this coil will produce magnetism almost at right angles to that of coils I and II. In fact, if the magnetism of these two coils were represented by an arrow pointing vertically downward, that of coil O would be almost horizontal.

It is well known that unlike poles of magnets attract each other, and this attraction of poles causes the coil to tend to rotate in a clockwise direction. This rotation is opposed by the pull of an adjustable spring F, which maintains practically constant tension on the arm of the pivoted coil.

Day Operation.

In order to explain the operation of the equipment, we will assume first that it is operating in the day time with no lights. As soon as the train gets up to cutting-in speed sufficient voltage will be developed to cause the regulator voltage coils to operate and rock the pair of regulator shoes R. As soon as this opens up the first segment, it causes current to flow through the magnet P, this pulls down the movable arm of the auto-switch C, connecting the generator to battery. Since the generator voltage is then slightly above that of the battery, current will flow through the coil II to the battery. Since the magnetism of II adds to that of I, it will increase the turning force of the movable coil O and rock the two contact shoes slightly. A further increase in speed will cause a corresponding rise in voltage and this rise in voltage causes a great increase in the battery current. This increase in battery current, however, flowing through coil II will still further strengthen the turning force of the coil O and rock the shoes R further, cutting in more resistance and maintaining the generator voltage at approximately normal value. A single rocking contact shoe is shown in the diagram for simplicity. There are actually two shoes placed diametrically opposite as shown in Fig. 175.

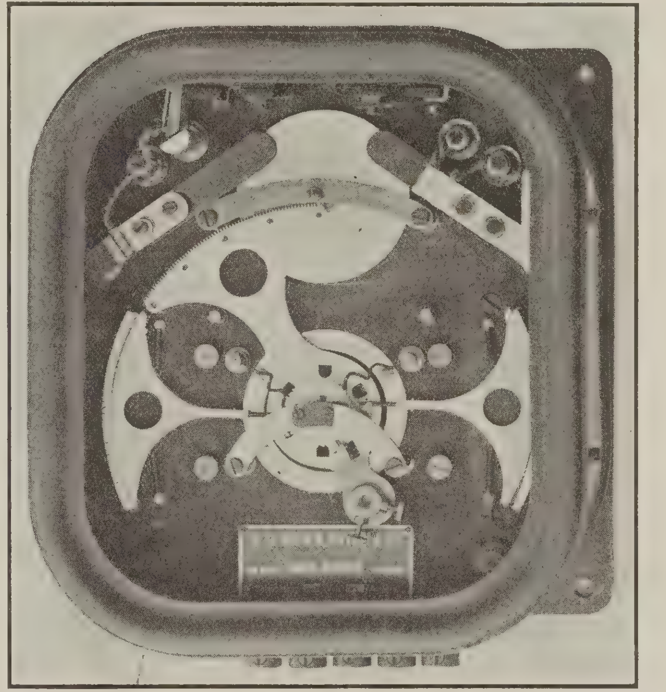


Fig. 175. Regulator of Brown Boveri (German) System. Coil in Center Rotates, Rocking Contact Shoes Over Segments of Field Resistance

As the battery becomes nearly charged its voltage will rise gradually and since the current flowing through O and I is proportional to the generator voltage, this will gradually increase the turning force of the coil O and automatically cut in the field resistance, thus reducing the generator voltage considerably at the end of the charge. It will thus be seen that this is a voltage current or, taper charge regulator, very similar in results of its operation to some of the more modern American equipments. It will control the equipment substantially on a combination current-voltage principle, providing a fairly high battery current flow a the beginning of charge and tapering this down to a low value near the end of charge.

Stop Charge Device.

When the voltage of the battery reaches a certain value, which is assumed to be the full charge voltage, the magnet N attracts its armature and closes contact.

It will be noticed that the winding magnet of the U is in series with I and O, and also half of the resistance H. When U operates, however, it connects the other half of resistance H in parallel with its own winding and the first half of this resistance thereby increasing the current flowing through I and O. This will considerably increase the turning force of the rotating coil and by rocking R and inserting more resistance in the generator field circuit, considerably reduce the generator voltage. The resistance H and the coil and U are so proportioned that when U closes, the generator voltage is cut down to approximately floating voltage of the battery.

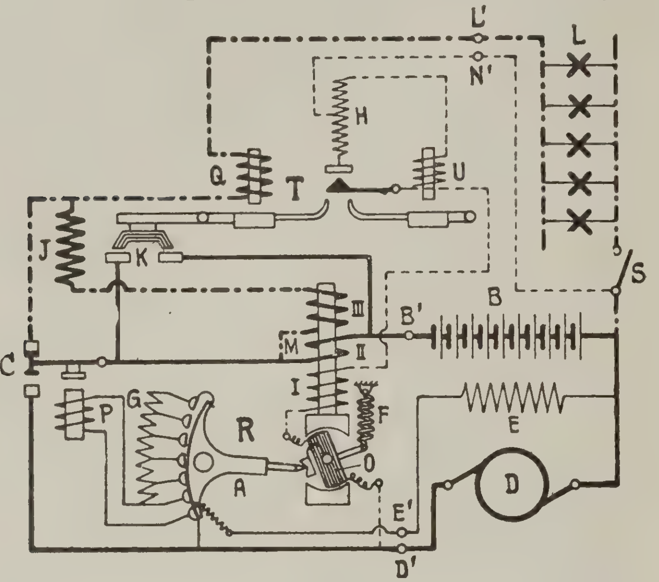


Fig. 176. Wiring Diagram of Brown Boveri (German) Axle Lighting System

Lamp Voltage Regulation.

Since the magnetism of the coil III opposes that of the main coil I, it will weaken the magnetism of that coil and cause the generator voltage to be increased slightly in proportion to the number of lamps turned on. This is simply to overcome the tendency of the generator voltage to fall off as the load increases and also partly removes the objection of a fixed resistance in the lamp circuit. With a few lamps on, the voltage drop through this resistance will, of course, be slight, but the generator voltage will then be maintained at a lower value by the main regulator. On the other hand, a heavy lamp current will cause a fairly large voltage drop in this fixed resistance, but the generator voltage is then maintained correspondingly high by the regulator. Therefore, if these are properly proportioned a fairly constant lamp voltage should result.

A Novel Dash Pot.

In order to keep the regulator from surging, a function which is performed on American equipments by an air or glycerine dash pot, a novel device is employed as follows: A section of a gear is cut on one of the arms carried by the rotating element and this meshes with a very small pinion mounted on the same shaft with a large aluminum damping disc. This disc rotates between two permanent magnets and a slight movement of the rotating coil will cause a large movement of this damping disc. The permanent magnets retard any sudden movement of the damping disc and this in turn controls the regulator itself.

The operation of stop charge devices on American axle lighting systems has conclusively proven that the battery voltage at the end of charge cannot safely be assumed as a definite and fixed value, as is done in this system. Therefore the same operating difficulties in this particular respect as has been experienced on American equipments might be expected with this equipment.

Night Operation.

When lamps are turned on at night this current flowing through the solenoid Q closes contact both at T and at K. The first contact has the same effect as operating the stop charge relay and this causes the generator to operate at practically floating battery voltage, the other contact K, which is operated by the same solenoid, short circuits the battery coil II and the lamp current coil III of the main solenoid when the equipment is at rest.

When the train gets above critical speed, however, and the regulator opens up its first segment, the magnet P is energized and pulls down C. The generator voltages than being above the battery voltage, furnishes current for the lamps, but this current must then flow through the coil III and resistance J. The resistance J is proportioned so that with all lamps on, the difference between battery voltage and lamp voltage will be about equal to the difference between floating voltage and battery voltage on discharge.

Prize Question Box

This "Question Box" is open to every electrical man in the Mechanical, Signal and Telegraph, as well as Car Lighting Departments. We feel that this can be made a mighty valuable thing, so as a special inducement to the boys to boom it, we offer prizes for the best questions asked, as follows:

First prize	$1.00 *in cash*
Second prize	9 *months' subscription*
Third prize	6 *months' subscription*

There are some questions that are of a general nature, which should have comments of prominent men of experience. These will be published under "Questions Before the House," and we hope that prominent railroad men and manufacturers will discuss these questions. All answers published will be paid for at $1.00 each.

System of Handling Repairs to Axle Equipment.

No. 7. What is the best method of handling repairs to axle devices? That is, is it better to make repairs on each device enroute or at terminals as soon as the trouble develops or, by having a few spare equipments, simply replace the complete board or the complete generator which is giving trouble and make the necessary repairs in the shop?—L. S. Billau.

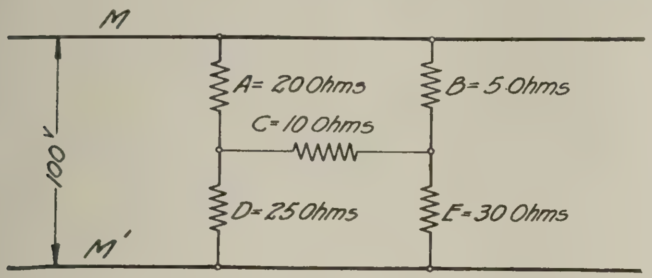
Generator Grounded Field Coil in Moskowitz.

No. 10—While motoring a Moskowitz generator, the automatic switch, after being closed, had a tendency to stick quite tightly in position and immediately release, in the same revolution of the armature. This effect was maintained as long as the switch was held in the operating position. In motoring this machine in the opposite direction, it was found to work perfectly. After carefully looking over the generator, it was observed that one field-coil was grounded. After removing the ground, the auto switch worked perfectly in either direction.

What caused the automatic switch to act in this manner? Why did the grounded field coil effect its operation only in one direction?—H. W. Millard, Santa Fe.

Solving Complex Circuits

In applying Ohms Law to the solution of divided circuits I came upon the following problem which I would like to know how to solve. In the accompanying figure, assuming a potential of 100 volts between the wires M M′, what current will flow in each of the 5 branches, A. B. C. D. & E. f their respective resistances are 20-5-10-25-35 ohms.



Fred Loweth, Buffalo, N. Y.

Commutator Short in Wave Wound Armature

When testing a four pole wave wound armature for short-circuited commutator segments with a telephone receiver, a curious result was obtained. Not only was a short indicated at the point of the actual short circuit but also at the opposite and quarter points on the armature.

Why did the telephone receiver indicate shorts at these four points?

G. B. Billings, Topeka, Kans.

What Is the Life of a Storage Battery?

In traveling about the country I hear a good many arguments, and, while most of them are usually settled in some manner, there is one question which no one has ever offered an answer to that seemed to cover it definitely.

It is impossible to mention batteries without referring to their life and up to the present I have never met anyone who can bring forward any method of computing it that would be considered practical.

Like everything else, I believe some standard should be agreed upon in connection with the life of a battery whereby anyone should be able to determine when a battery is fit to continue in service.

By the above statement I do not mean that a person should be called upon to guarantee the life of any battery, but I do claim that when the efficiency or capacity has dropped to a certain point, it would then be considered fit for scrapping.

A good many men consider a battery useless only when the parts have refused to hold together any longer. This is unfair, as I have already seen elements which appeared as good as new, but which were unable to deliver over 1-5 of their rated capacity.

We consider an incandescent lamp worn out when it has dropped to 80% of its initial candlepower. How about 60% A. H. efficiency at the 8-hour rate?

A Car Lighting Batteryman.

Axle Generator Troubles.

In motoring a type "A" Consolidated dynamo recently the dynamo would make an attempt to motor in the same direction immaterial of the position of the pole changer, and in each case the main fuse would blow. In connecting the generator afterwards, the positive and negative generator leads became reversed and the machine immediately started motoring with the auto switch closed and the main fuse out. Was this due to the generator being grounded? —G. B.

Ampere Hour Meters in Car Lighting Service.

What attention has it been found necessary to give ampere hour meters in car lighting service to maintain them properly? How frequently should they be removed from cars and taken into shop for thorough overhauling?—L. S. Billau, B. & O. Ry.

Scale on Battery Bridge.

Q. After a battery has been in service for 3 or 4 years and a plate breaks off from either group and you try to burn another plate on with an arc, I have found that a scaly hard substance is deposited on top of the bridge, which the arc will not penetrate, while on the under side of the bridge there is no such hard scale and an 8 volt arc will easily deliver 160 amperes. Why does this scale exist on the top of the bridge and not on the under side? What is it composed of, and what causes it to form?—E. J. Galloway, Oakland, Calif.

Ground on Type "K" Relay.

What effect will a ground on a type K relay have on the operation of the U. S. L. equipment?—Frank M. Burke, Pullman Co., Jersey City.

First Prize

Motoring E. S. B. Dynamo.

"How do you motor an E. S. B. Dynamo?"—M. F. Hand, Santa Fe.

Ans. (1) Release the belt tension, or preferably, remove the belt entirely, close the main automatic switch and at the same time start the machine by hand in the desired direction, holding the switch in the closed position as long as rotation of the machine as a motor is desired. The machine will run as a motor in either direction, depending on the direction in which it is started.

(2) If the closing of the main switch and the starting of the machine by hand cannot be accomplished simultaneously, substitute fuses of 150 ampere capacity for those in service, and proceed as above, starting the dynamo by hand as soon as possible after the main switch has been closed.—J. Lester Woodbridge, Chief Engineer of Electric Storage Battery Co.

Criticism September Stunt

Emergency Welding.

The stunt "Emergency Welding" which appeared in the September issue of the *Railway Electrical Engineer* should not be recommended for the folowing reasons: 1st, the battery manufacturers, their representatives and all their literature state—never go near a battery with an exposed flame. Second: Considering some of the serious physical injuries that might result from an explosion, it is not in harmony with the great "Safety First" movement. Conclusion: By all means cut out the tray and spare the eyes.

C. H. Hildebrant, Edison Storage Battery Co.

Ball Bearings for Car Fans.

To the Editor:

In the issue of the *Railway Electrical Engineer* for September, 1914, under the editorial caption "Better Bearings for Car Fans," emphasis is given the fact that "one of the chief sources of trouble to the terminal electrician at this time of the year is fan bearing failures, and trouble from fans throwing oil from flooded bearing." You also state that bearing failures on electric fans increase maintenance costs, terminal electrician's troubles and are "frequently brought to the attention of the railway management in damages for clothes, Pullman carpets, rugs, etc., damaged by oil thrown from the fan." Furthermore, you state "it seems strange that with such extensive application of ball-bearings to railway car lighting generators, their application to car fans, of which there are fully twice the number in service, should have been given so little consideration by both railroads and fan manufacturers."

We believe you will be interested to know that the Safety electric fan for railway cars, as described and illustrated on Page 99 of the August, 1914, issue, uses ball bearings throughout. The motor used with this fan is a ball-bearing motor, and in addition, the paddle fan, as well as the air deflector, travel on ball-bearings. In the development of this new type of railway fan, The Safety Car Heating and Lighting Company was fully appreciative of the advantages to be obtained by the use of ball bearings in the reduction of maintenance costs, elimination of failures and the avoidance of damages from oil flooded plain bearings; and in addition, was fully appreciative of the advantages to be gained with a fan directing the air velocity where needed in a railway car.

We believe that possibly your article may convey to your readers the thought that no fan has as yet been developed with ball bearings. Therefore, suggest that the progress made by this company in fan development be given recognition in your publication.

L. Schepmoes.
The Safety Car Heating and Lighting Company.

The Railroad Electricians' Club

Meetings the 3rd Monday of Every Month, 8 P. M.—18th Floor Transportation Bldg., Harrison and Dearborn Sts., Chicago—Everybody Welcome—No Dues

Lead Storage Battery Questions

Prob. 30. What is the maximum safe current that can be taken from a 300 ampere hour standard car lighting battery?

Ans. 30. It is impossible to answer this question definitely, for the maximum amount of current that can be taken from a battery would depend upon temperature, type of battery, its condition, length of time current must be delivered, etc. For a short period of a few seconds most car lighting batteries will give as high as 1,000 amperes discharge on short circuit or connection to a resistance of very low value. Some batteries are able to stand such a short circuiting current without apparent injury, but this is, of course, very unusual service for any battery to operate under.

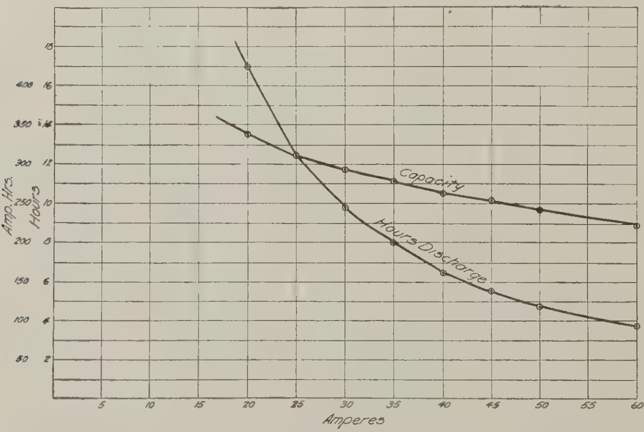
For regular car lighting service it is customary to figure on a maximum discharge of 40 to 60 amperes for a 300 ampere hour battery. This is only a little above the standard 8 hour rate.

Prob. 31. When you speak of a 300 ampere hour battery, does it mean it will give 100 amperes for three hours? (a) How long would a 300 ampere hour battery hold up voltage when discharged at a rate of 60 amperes? (b) How long would it hold up when discharged at the rate of 40 amperes? (c) How long would it hold up when discharged at 10 amperes?

Ans. 31. No, a 300 ampere hour battery will not give 100 amperes for 3 hours. It will, however, give 37 amperes for 8 hours. All car lighting batteries are rated on an 8-hour basis, that is, the number of ampere hours the battery will deliver when approximately 8 hours are allowed for the discharge. The end of the discharge is determined arbitrarily by the fall in voltage to 1.8 volts per cell for a lead battery and about 1.1 volts per cell for an Edison battery.

We know that when the discharge current of a storage battery is suddenly increased, its terminal voltage falls off slightly, therefore, on discharging at the heavy rates the battery voltage would fall to the minimum value of 1.8 volts more quickly in proportion to the number of ampere hours discharge than it would on weak discharge current.

The accompanying chart shows the variation in battery capacity of a Plastic type lead battery with various discharge rates. (A) It will be noted from this diagram that on a 60 amp. rate the battery will discharge 3 hrs. 45 min. and will give 225 amp. hrs. total capacity. (B) From the diagram it will be seen that at the 40 ampere rate the battery will discharge 6 hrs. 45 min. representing a total capacity of 265 amp. hrs. (C) At the 20 ampere rate the battery would hold up for 17 hrs. representing a total capacity of 340 amp. hrs. It is very evident from this data that the capacity which a battery will deliver depends entirely upon the rate of discharge.



Curves Showing Variation of Capacity and Hours Discharge of Lead Battery.

Prob. 32. How can you tell when a battery has become completely discharged?

Ans. 32. As stated in a preceding problem, the battery voltage falls off rapidly near the end of discharge. When this voltage reaches 1.8 volts per cell for the lead battery and 1.1 volts per cell for the Edison battery, it is then falling rapidly and this point is arbitrarily assumed to be the end of discharge. Of course the battery discharge could be continued further and a few more ampere hours taken from the battery, but this might injure it and the gain in amp. hrs. would be very slight.

Prob. 33. When a car is received in the yards what tests should be made to see whether the battery is sufficiently charged or not?

Ans. 33. There are three ways you can get an idea of the condition of a battery: (1) voltage readings, (2) specific gravity, (3) ampere hour meter readings.

(1) A voltage reading gives only a very rough idea of the battery condition and care must be taken in making even this simple test. The open circuit voltage of a battery means absolutely nothing; even a low battery, when the lights are first thrown on, may show a high voltage. Always turn the lights on and let the battery discharge for about five minutes before taking a voltage reading to determine condition of the battery; a low battery will usually be shown by that time.

Voltage readings will not tell you anything definite about what capacity is left in the battery. This can only be determined by either gravity readings on the ampere hour meter.

(2) Specific gravity; a pilot cell for gravity readings should be selected in each battery and the gravity of this cell when the battery is fully charged should be frequently adjusted with care, to 1,200.

If this is done the gravity of the pilot cell will show fairly accurately the condition of the battery.

(3) Ampere hour meter readings; in order for an ampere hour meter to tell you anything about the battery condition it must be permanently installed on that car. It merely records ampere hour discharge and charge which the battery receives en route or in the yards, running clockwise on discharge and reverse on charge.

The reading of the meter then shows whether the battery is fully charged or more correctly, the number of ampere hours it is lacking from being fully discharged. In order to tell how many ampere hours you have left in the battery you must know the total capacity of that battery and figure the difference between this and the reading of the ampere hour meter.

Prob. 34. The open circuit voltage of a generator tells whether the generator is up to voltage or not, so when you measure the voltage of a battery with no discharge current flowing, why doesn't this give you an idea of the battery condition.

Ans. 34. The voltage delivered at the terminals of a generator is the total electro-motive-force generated in the windings of the armature, less the voltage drop of the current flowing through the armature. Since the resistance of an armature is usually very low, this voltage drop is low and the open circuit voltage of the generator shows fairly well whether or not it can deliver its full load voltage.

With the storage battery on the other hand, the voltage delivered at the terminals is the electro motive force generated by the plates, less the resistance drop (volts required to force that discharge current through the ohmic resistance of the battery) less something else, which might be likened to the polarizing effect of a dry cell. That is, as soon as the current starts flowing, a chemical action takes place within the plates of the battery, which both decreases the electro motive force generated and opposes the flow of discharge current. In a lead cell discharge current causes sulphate to flow from the electrolyte into the plates, where it combines with the active material.

The voltage of a storage cell is generated at the point where the electrolyte makes contact with the active material of the plates. For purposes of illustration we will assume that when a battery is nearly discharged, all of the active material, except a layer deep in next to the lead grid, has been sulphated and therefore the voltage must be generated between this active material and the electrolyte, which has diffused through this thick wall of dead or sulphated active material.

In order for a battery to generate current, sulphate must be delivered to the active material at a certain rate, this depending on the amount of current flowing. On open circuit or very low current flow, the sulphate of the electrolyte would be able to diffuse through this dead wall of sulphated active material fast enough to supply the live active material and so deliver full voltage. If a heavy discharge current is thrown on the battery, however, the diffusion of sulphate through the dead active material of the plate would not be fast enough to supply the live active material underneath. The electrolyte in the pores of the plate immediately adjacent to that live active material will then be quickly depleted of sulphate and this will have the same effect as immersing normal battery plates in very weak acid . . . . a low voltage will be generated. In addition to this effect, we will have a counter electro motive force developed at the point where the weak acid within the plate comes in contact with the strong acid near the surface. This layer of very weak acid surrounding the live active material, moreover, will have a high resistance and increase the ohmic resistance of the battery.

There are three factors then, that cause the voltage of a discharged battery to rapidly fall when load is thrown on: (1) Reduction of electro motive force generated; (2) increase in ohmic resistance of the battery, and (3) polarizing or counter electro motive force effect due to the different densities in the electrolyte.

Prob. 35. How quickly can a 300 ampere hour standard car lighting battery be given a complete charge?

Ans. 35. The maximum number of amperes current which can be forced into a battery on charge depends largely upon the temperature of the battery. There is practically no limit to the amount of current which can be forced into a battery at the beginning of charge so long as the temperature is kept below normal. Twice normal current will cause four times the heating effect in the battery and three times normal current will cause nine times the heating effect in the battery, etc., so it is seen that high current rates greatly increase the battery heating. In the winter time a battery may be charged quicker than in the summer time, although in extremely cold weather it will require a rather high voltage to do so.

In general, it may be said that a car lighting cell of 280 ampere hours capacity may be fully charged with the constant potential system in about 3 hours. The current would probably start at nearly 300 amperes, but taper off to a low value near the end of charge. Manufacturers of the Wilson battery claim that it can be charged in 1½ hrs. and recommend that it be charged intermittently, a current of 1,500 amperes being forced into a 400 ampere hour battery for 3 minutes, the battery then resting for a minute and a half without charge and the 3 minute charge repeated, etc. The current rate is tapered down considerably as the charge proceeds.

Prob. 36. What is the proper amount of current to give a 300 ampere hour battery on charging?

Ans. 36. Manufacturers used to recommend that batteries be charged with a constant current at the normal 8 hr. rate. During the past two years, however, the constant potential method of charging has become generally used and is giving more satisfactory service than the older constant current method.

If the battery is charged with a constant current this should be. for a 300 ampere hour battery, 37.5 amperes. If the constant potential method of charging is used, however, when the battery is first connected to the circuit of constant potention, the charging current may run up to 300 amperes if the battery is low. This current, however, will quickly taper down to a reasonable value around 100 amperes and will then begin to gradually taper off so that near the end of charge there may be from anything 1 to 40 amperes going into the battery, depending upon the potential of the system.

Prob. 37. What is the difference between charging a battery at constant current and charging it at constant potential?

Ans. 37. When a battery is charged at constant current its terminal voltage gradually rises until near the end of charge, when the battery begins to gas and this causes a sudden rise in terminal voltage to a maximum value. Even though the charge be continued at constant current indefinitely, the voltage will not rise above this value. As a matter of fact, if the battery warms up sufficiently, due to this current flowing through it, it will actually cause the terminal voltage of the battery to decrease, due to the increased temperature. An adjustable resistance is usually placed in the battery circuit and this gradually cut out of circuit by hand as the battery voltage rises, in order to keep the battery current constant. With constant current axle generator regulators, of course, no such resistance is required.

Where batteries are charged on constant potential, a certain voltage is decided upon, depending upon battery voltage, type, etc., and a fixed resistance of low value is placed in each battery circuit. All batteries then, regardless of what their condition of charge is, are connected, each through its individual resistance, to the charging line. The low batteries will take a very high charging current at the start because of their low counter electro motive force or back voltage, and the batteries more fully charged will take a lower current, as their counter electro motive force is higher. As the charge proceeds, this counter electro motive force will gradually rise and cause the current to taper off to a low value.

Prob. 38. How can you tell when a storage battery is fully charged when it is, (a) charged at constant current, (b) charged at constant potential, (c) charged at constant current with taper charge at the finish.

Ans. 38. (A) With batteries charged at constant current, the end of charge is indicated by (1) the voltage ceasing to rise further; (2) the gravity ceasing to rise further; (3) return of the ampere hour meter needle to zero, (if a compensated ampere hour meter of the resistor or differential shunt types is installed permanently in the circuit and has recorded all previous discharge).

(B) When a battery is charged and at constant potential, the end of charge is indicated by (1) gravity ceasing to rise further, (2) return of ampere hour meter needle to zero.

(C) With a battery charged at constant current with a taper charge at the finish, either the gravity or ampere hour meter readings are necessary to indicate the full state of charge. Some types of axle equipments operate on this taper charge principle without gravity or ampere hour meter control, and seem to be giving satisfactory results. This is undoubtedly due to the fact that the battery current is tapered to a low value but not cut off, when the battery voltage rises to a certain value near the end of charge.

Prob. 39. Why isn't the battery voltage at the end of charge reliable for stopping the charge?

Ans. 39. As stated in a previous problem, the voltage of a storage battery rises suddenly near the end of charge to a certain value and then ceases to rise further even though the charge be continued indefinitely. This maximum voltage, however, is not a definite or fixed value, in fact, it is affected by many things, such as the number of amperes charging current, temperature, strength of electrolyte, condition of the battery, etc.

Nearly all voltage controlling devices, for batteries particularly for car lighting systems, have assumed that this voltage at the end of charge was a certain fixed value summer and winter, and under all conditions of service, but as mentioned above, this voltage varies widely and such stop charge devices that assume it to be constant can only meet with temporary success.

Prob. 40. Why can't you use an automatic hydrometer for stopping the battery charge on an axle generator system.

Ans. 40. An automatic hydrometer for controlling the charge of an axle lighting system is impractical for several reasons: (1) The gravity of the electrolyte varies widely with changes in temperature, a variation of even 30 deg. F. would cause an error of 10 points in the operation of the hydrometer. (2) It would be difficult to adjust the gravity of a pilot cell to the proper value and, as is well known, the level of the solution and gravity change very considerably in even a few weeks' service; (3) The mechanical and electrical connections for such an automatic hydrometer would probably be too complicated and difficult to warrant their use.

Problems for Next Month

Lead Battery Questions, Continued.

Prob. 41. What are the advantages and disadvantages of a constant potential yard charging system?

Prob. 42. What are the advantages and disadvantages of a series yard charging system?

Prob. 43. What are the advantages and disadvantages of an individual circuit control yard charging system?

Prob. 44. What causes a battery to warm up when it is either charged or discharged?

Prob. 45. What is the highest temperature a battery should be operated at? What will happen if the temperature goes above that value?

Prob. 46. Why is it that a warm battery will charge at a lower rate and give a higher rate on discharge than a battery at normal temperature will?

Prob. 47. Why will a battery that is extremely cold, say around zero degrees F., require a charging voltage considerably higher and give a discharge voltage considerably lower than the same battery would at normal temperature?

Prob. 48. Can the electrolyte of a lead battery freeze? What happens if it does?

Prob. 49. What causes the specific gravity of a battery to rise as the battery becomes charged and to fall as the battery discharges?

Prob. 50. Why does it take a higher voltage to force 40 amperes through a car lighting battery at the end of charge than it does at the beginning?

Prob. 51. What causes a battery to gas, and why does it gas at the end of charge and not at the beginning?

Prob. 52. What causes a storage battery to explode sometimes when a light is brought near?

Prob. 53. Is it necessary to make a battery gas when charging it?

Prob. 54. Does excessive gasing of the battery injure the plates?

Prob. 55. Is it necessary to give a storage battery an overcharge occasionally?

A Communication on Ball Bearings.

To the Editor:

When, on the first of August, communication with our Berlin factory was interrupted, we had approximately one-half million bearings in stock. With the exception of a few sizes in which a shortage was caused by an unusually heavy demand, our stock was well balanced and large enough to supply the demands of our regular customers for several months.

Upon learning that we could not depend upon our usual source of supply, we took steps to provide bearings in those sizes where shortages occurred. As our manufacturing facilities were inadequate we deemed it advisable to have a portion of the work done by outside parties rather than seriously delay and inconvenience our customers, to whom we feel morally obligated even though we have been much handicapped by conditions over which we have no control.

Rings in various stages of completion (which will be finished in our own factory) and in some cases complete bearings, particularly thrusts, are being made for us. In all cases this work is being done in accordance with our specifications and must pass the same rigid inspection, to which all our imported bearings are subjected.

All bearings sold by us are subject to our usual guarantee covering defects of workmanship or material developed within one year.

Our own manufacturing facilities are being increased as rapidly as is consistent with the production of first quality bearings. Our experience as ball bearing manufacturers covers a period of over nine years, and thousands of bearings made in our factory are giving most satisfactory service.

Although bearings are now being shipped to us from Berlin, we are proceeding on the entirely independent basis of manufacturing here.

Many of our customers have expressed their approval of our decision to manufacture in this country and have in other ways shown a spirit of co-operation and loyalty in the present rather trying situation, which is most gratifying and highly appreciated.

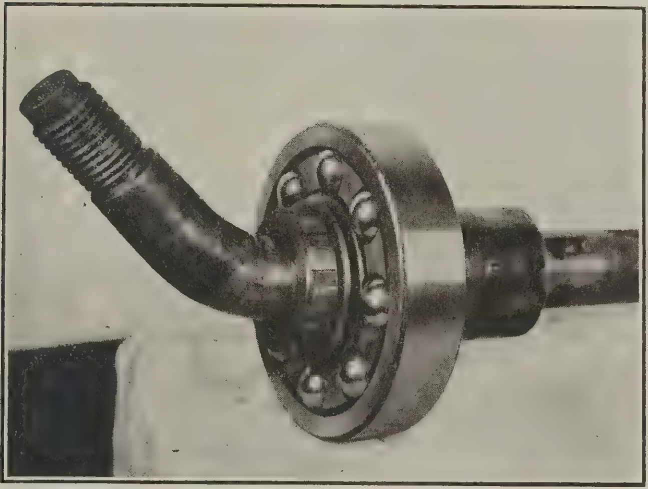
(Signed) THE HESS-BRIGHT MFG. CO.

Practical Stunts

We Pay a Dollar Apiece for Practical Stunts—Send in Your Ideas

Strength of Ball Bearings

The accompanying illustration is a striking example of what the standard No. 412 size ball bearings now applied to car lighting generators will stand. This is an armature shaft taken from a car lighting generator which had been in a wreck. The shaft, which was of 1½ in. forged steel, was bent over the ball bearing as a fulcrum. From the illustration it will be noted that although there is no crack in the steel at the bend, there is a double wrinkle on the top side, which gives an idea of the great stress imposed on the ball bearing when the wreck occurred.



Armature Shaft Bent in a Wreck; Ball Bearing Uninjured

Assuming an ultimate strength of 60,000 lbs. per square inch, it would require a force of 79,000 lbs. applied 3 in. from the face of the bearing, to bend this shaft. As a mater of fact, it would require 100,000 lbs. to crush a single ball of this bearing, so that even under such severe service as a wreck, we still have a reasonable factor of safety for the ball bearing. It is interesting, however, to see a practical demonstration of this fact, as shown by this illustration.

The car to which this generator was applied was a Santa Fe combination coach and mail car. The accident, which occurred on the Colorado Southern tracks in Colorado, was caused by high water, the engine going through a culvert, with the baggage car on top of it and the combination coach and mail car crashing on top of that.

The dynamo pulley was entirely broken up, only the hub remaining. The suspension of the dynamo, which was a Bliss type, "O," was badly bent and the generator frame was sprung out of round, so that two of the pole faces bound on the armature, causing trouble in removing it. The armature itself, which was mounted on two S. K. F. ball bearings of the No. 412 size, was not damaged in the least and as soon as a new shaft was applied it was ready for service. Neither of the ball bearings showed any effect of their strenuous experience and are both going right back into service. Both end housings of the generator covering the bearings were badly broken so that they had to be scraped.

This will no doubt serve to strengthen our faith in the reliability of ball bearings in car lighting service. —C. B. Jennings, Santa Fe R. R., Topeka, Kan.

Combination Hammer and Tension Rod Nut.

To the Editor:

A number of the car lighting boys have asked what the little bosses on the U. S. L. tension takeup nuts are for. When an inspector has occasion to renew a belt on an axle lighting equipment he must necessarily slack up the belt tension and in doing so, he might just as well take one of the tension nuts or handles completely off the tension rod and use this as a hammer for driving rivets in the belt. A hammer is a rather heavy and awkward tool to carry around and it occurred to the writer some time ago that this takeup wrench could easily be converted into a good hammer by casting the hammer face on one edge, the other boss is added simply to make the wrench symmetrical. If you try one of these handles in this manner you will find that you can do a pretty good job of hammering with it.

W. L. Bliss.

Grounded Field Coil in Moskowitz Generator.

No. 10—While motoring a Moskowitz generator, the automatic switch, after being closed, had a tendency to stick quite tightly in position and immediately release, in the same revolution of the armature. This effect was maintained as long as the switch was held in the operating position. In motoring this machine in the opposite direction, it was found to work perfectly. After carefully looking over the generator, it was observed that one field-coil was grounded. After removing the ground, the auto switch worked perfectly in either direction.

What caused the automatic switch to act in this manner? Why did the grounded field coil effect its operation only in one direction?

Santa Fe. H. W. Millard.

Interesting Results of Ball Bearing Operation.

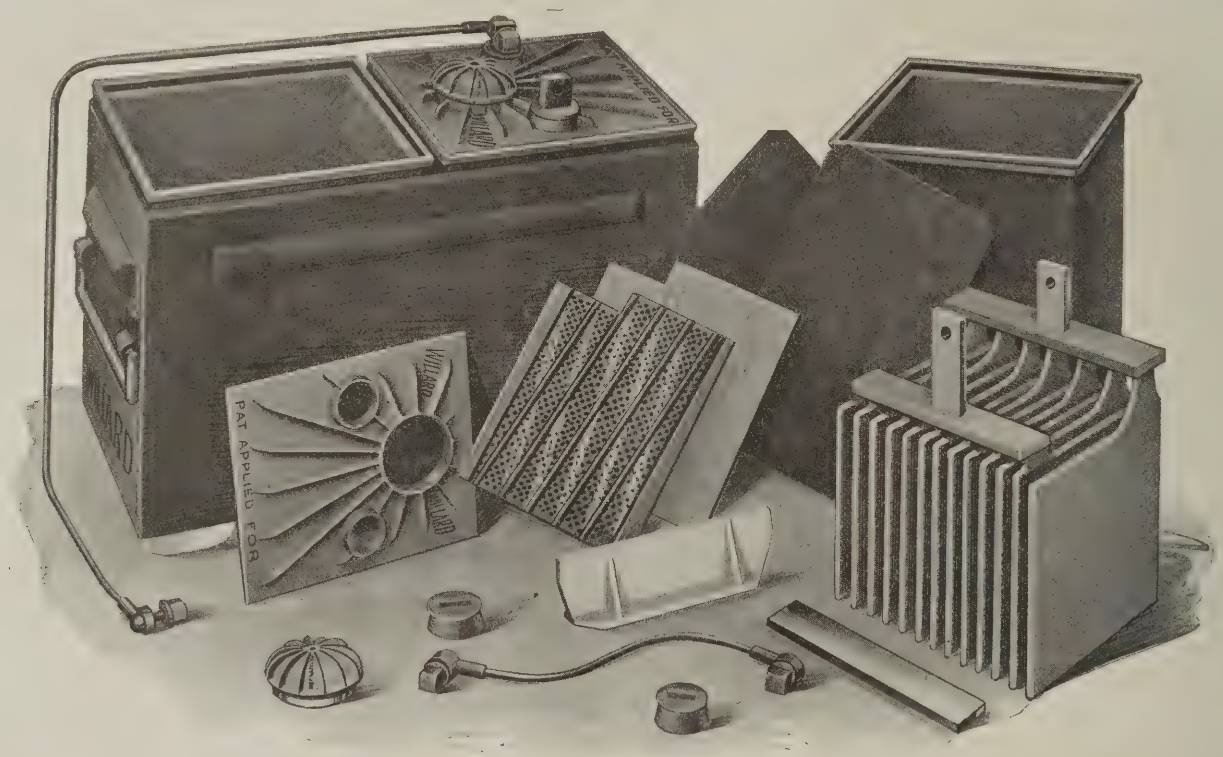
In view of the fact that the period of greasing car lighting bearings has been gradually lengthened from frequent charges with a grease gun to a schedule of once in six months as is now maintained on most of the railroads, it will be interesting to learn of similar experience with lubricating ball bearings operated in mine locomotives, a service which is possibly even more severe than that of railway car lighting. The Hess-Bright Mfg. Company quotes us from a letter from the Big Five Mining Co., of Denver, Colo., which accompanied a large order for ball bearings, as follows:

"We have heretofore given you results of draft tests of this bearing. We find lubricant needs renewal only about once a year. When examined recently the bearings in use showed no perceptible wear and our conditions are about as difficult as any can be."

It will be interesting to learn if ball bearings in car lighting generator service could be operated for a whole year without any attention.

Willard "No Wash" Battery

One of the chief items of expense in connection with storage batteries in railway car lighting service is that of battery cleaning. The successive developments of storage batteries for car lighting service have usually been with a view to extending the length of time between necessary cleanings and increasing the life of the battery.



Parts of Willard "No Wash" Battery

The latest development of the Willard Storage Battery Co. is a battery which is so designed as to require no cleaning whatever throughout its entire life—it is known as the "No-wash" battery, NWL type. There has been no change whatever in the plate construction or formation of the Willard standard car lighting battery, therefore the same excellent qualities as to life and service may be expected in the new battery as has been found in the past. The dimensions of the "No-wash" battery are the same as P. R. L. type battery, formerly their standard for car lighting service, so there will be no alterations in the battery box necessary where the new battery is installed.

The battery is provided with a substantial lead cover burned to the cover frame of the lining, as shown in the accompanying illustrations. Numerous radiating fins are cast on the lead cover so as to permit the battery to more effectively cool itself. A 3 in. opening with very substantial cover cap is provided for the purpose of inspection and flushing without removing the cell cover. Car lighting maintainers will welcome this large flushing and inspection pole as it enables them to flush the battery without special apparatus and there is no danger of slopping the water over the battery tank, causing grounds, etc. In this flushing opening is fitted securely an expansion dome of lead with radiating fins, on the same principle as the cover. While this dome fits securely in the hole, it is very easily removed, a feature of special interest to the men in the yards on a cold day. This vent dome combines the function of a plug and ventilator and also acts as an anti-slop device. The cover is also provided with standard openings for bushings, and is securely lead burned to the cover frame of the lead lining to prevent any slopping of the electrolyte.

The rubber parts used in this battery are of the highest quality, tested for tensile strength before leaving the rubber factory and again before being assembled in the battery at the Willard factory. The separators are of special design and are supplemented by doubly treated wood separators, which materially assist in prolonging the life of the "No-wash" battery. The connectors used on this battery are of special design of the bolted type.

The Willard Storage Battery Co. considers this no-wash battery their masterpiece, and their faith in its complete success is so strong, that they are standing back of it absolutely, and taking the responsibility for its successful operation.

New Fixtures and Fittings for Multiple Mazda Lamps.

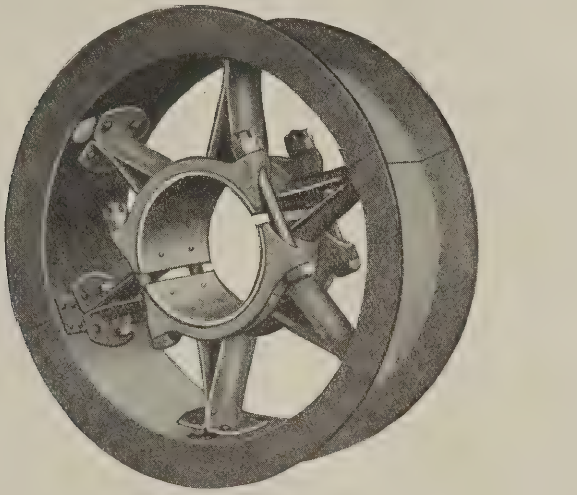
A remarkable increase in efficiency which has made the new high candle power Mazda lamps practical has been the subject of considerable comment in electrical circles. These new lamps are highly efficient, have excellent color quality and provide an approximate point source of light which is of special advantage in the design of reflectors. The extreme intensity of this light, however, makes it necessary that some form of diffusing globe be used.

The Holophane Works of Cleveland have prepared a booklet with the same title as this article in which they describe fixtures and fittings to be used with this new type of lamps. They show distribution curves for their different types of reflectors and diffusers.

For engineers who are engaged in designing lighting installations this booklet should prove to be a great help. From the great variety of reflectors described one should be found for almost any requirement. This booklet may be had upon request to the Holophane Works, Cleveland, Ohio.

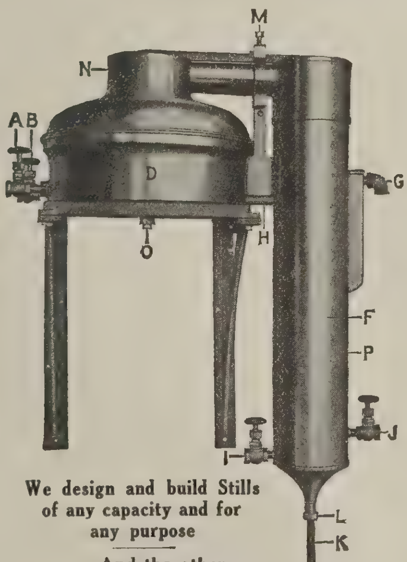
New Keystone Railroad Pulley.

The Oneida Steel Pulley Co., has recently placed on the market a new flanged axle generator pulley. This pulley is very similar to the Keystone R. R. pulley, as shown in the accompanying illustration. It is provided with an extra heavy rim 3-16 in. thick and this has 1½ in. flanges all around. This pulley will be on exhibit at the A. R. E. E. Convention, Chicago, Booth No. 28-D.



Two Things
Every Railway Electrician Needs

One is—a
Rochlitz Water Still



Service and life is what you want and expect from your STORAGE BATTERIES.

DISTILLED WATER — Gives you this and more.

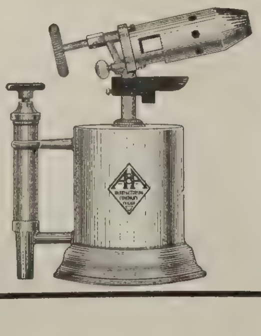
IMPURE WATER — Shortens life and decreases efficiency.

YOUR BATTERY TROUBLES—End with the installation of a ROCHLITZ WATER STILL. Standardized on Thirty-Five Railroads.

We design and build Stills of any capacity and for any purpose

And the other—a
Kerosene Blow Torch

Absolute Safety AT ALL TIMES.
Intense Heat - Less Cost
Burner Non-Carbonizing. Made of brass and Guaranteed.
Adopted by Leading Railways and Car Builders.
Ask us for prices and catalogues.



The A & A Manufacturing Co.
Manhattan Bldg., Chicago
W. M. LALOR, President

Committees

of the Association of Railway Electrical Engineers

Semi-Annual Convention will be held at Atlantic City, Friday, June 12th, Headquarters Hotel Dennis. Annual Convention October 26th to 30th, at Chicago.

PRESIDENT

C. R. Gilman, C., M. & St. P. Ry.

SENIOR VICE-PRESIDENT

H. C. Meloy, L. S. & M. S. Ry.

JUNIOR VICE-PRESIDENT

E. W. Jansen, Ill. Cent. Ry.

SECRETARY-TREASURER

Jos. A. Andreucetti, C. & N. W. Ry.

EXECUTIVE COMMITTEE

C. J. Causland, Penn. R. R. Lines East.
L. S. Billau, B. & O. R. R.
Wm. A. Del Mar, N. Y. Central.
J. E. Gardner, C. B. & Q.
J. J. Hack, So. Pac. Co.

COMMITTEE ON AXLE EQUIPMENT.

H. R. Bucks, Chairman, Chief Elec., Oregon Short Line.
R. T. Smith, Elec. Eng., Gt. West. Ry., England.
E. M. Cutting, Edison Storage Battery Co.

COMMITTEE ON DATA AND INFORMATION.

B. F. Bilsland, General Electric Co.
C. J. Causland, Pennsylvania R. R.
George W. Cravens, Cravens Electric Company.
W. A. Del Mar, Asst. Elec. Engr., N. Y. C. Line.
A. J. Farrelly, C. & N. W. Ry. Co.
J. E. Gardner, C. B. & Q. R. R.
W. M. Wiggins, Elec. Insp. Pullman Co
Edward Wray, Chairman, *Railway Electrical Engineer.*

COMMITTEE ON ELECTRIC TRACTION

H. M. Van Gelder, Chairman, Westinghouse, Church Kerr & Co.
J. H. Davis, Elec. Engr., B. & O. R. R.
D. C. Woodbury, N. Y. C. & H. R. R. R.
Paul Real, Ass't Engr., N. Y., N. H. & H. R. R.
Chas. P. Kahler, Elec. Engr., Oregon Short Line R. R.
C. B. Keiser, M. M., Penna. Lines East.

COMMITTEE ON ELECTRIC HEAD LIGHTS.

Chas. R. Sugg, Chairman, Elec. Eng., Atlantic Coast Line R. R.
Geo. E. Murrey, Chief Elec., Chicago Shops, C. & N. W. R. R.
J. J. Hack, Eng. Tr. Ltg., H. & V. Southern Pacific R. R.
Jno. E. Gardner, Elec. Eng., C., B. & Q. R. R.
L. C. Hensel, Chief Elec., St. Louis & San Francisco R. R.

COMMITTEE ON HEAD END EQUIPMENT

K. R. Hare, Chairman, Chief Electrician, N. P. R. R.
Jos. A. Andreucetti, General Foreman, C. & N. W. Ry.
C. R. Gilman, Chief Electrician, C., M. & St. P. Ry.
J. J. Hack, Engineer Train Lighting, Heating and Ventilating, S. P. R. R.

COMMITTEE ON ILLUMINATION

L. S. Billau, Chairman, Elect. Dept., B. & O. R. R.
J. L. Minick, Chief Draftsman, Penna. R. R.
H. C. Meloy, Chief Elect., L. S. & M. S. R. R.
L. Schepmoes, Safety Car Heating & Lighting Co.
D. P. Morrison, Elec. Engr., P. & L. E. R. R.
W. H. Rolinson, Westinghouse Lamp Co.
Preston S. Millar, Electrical Testing Laboratories.
C. W. Bender, National Elec. Lamp Association.

Sub-committee on Lamp Specifications.

J. L. Minick, Chairman,
J. R. Sloan,
Henry Rogers.

COMMITTEE ON INDUSTRIAL TRUCKS.

T. V. Buckwalter, Chairman, Penn. R. R.
C. E. F. Ahlm, Chief Engr. The Elwell-Parker Elec. Co.
H. G. Thompson, Vice-Pres. The Edison Storage Battery Co.
J. E. Hale, Experimental Engr. The Goodyear Tire & Rubber Co.
F. K. Fildes, Elec. Dept. Penn. R. R.
H. A. Currie, Ass't Elec. Engr. N. Y. C. & H. R. R. R.
A. H. Gfrorer, Mech. Eng., C. W. Hunt Co.

COMMITTEE ON LOOSE LEAF BINDERS FOR FILING SPECIFICATIONS AND TO KEEP SPECIFICATIONS AND STANDARDS TO DATE

J. R. Sloan, Chairman, Eng. Elec. Tr. Ltg., Penna. R. R.
J. L. Minick, Chief Draftsman, Penna. R. R.
T. V. Buckwalter, Draftsman, Penna. R. R.

COMMITTEE ON OUTSIDE CONSTRUCTION AND YARD LIGHTING

H. M. Warren, Chairman, Elec. Engr., D., L. & W. R. R.
W. H. Keirn, Elect., Penna. R. R.
Jos. A. Andreucetti, Gen'l Fore., C. & N. W. R. R.
C. J. Causland, Chief Elect., Penna. R. R. Lines West.
C. D. Axtell, Gen'l Fore., D., L. & W. R. R.
J. L. Minick, Penna., R. R.

COMMITTEE ON RECIPROCAL RELATIONS

L. S. Billau, Chairman, Elec. Dept., B. & O. R. R.
J. R. Sloan, Eng. Elec. Tr. Ltg., Penna. R. R.
Jos. A. Andreucetti, C. & N. W. R. R.

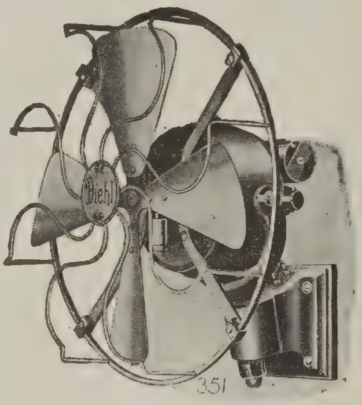
COMMITTEE ON SHOP PRACTICE

Geo. W. Cravens, Chairman, Manager Welding Apparatus Deparment, C. & C. Elec. & Mfg. Co.
R. F. Moon, Westinghouse Electric & Mfg. Co.
G. M. Crownover, Supt. M. P., Chicago-Great Western Ry.
L. C. Hensel, Chief Elec., St. Louis & San Francisco Ry.

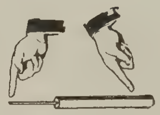
(Continued on Page 34)

The House

Our ability to make immediate shipment from an immense
to railroad orders. Your entire requisition for electrical
one order and you receive the goods in one shipment. Think



Diehl Car Fans, pleasing in design, give a finishing touch to passenger comfort. They have been designed especially to meet the severe conditions of railroad service. The fan body is readily removed from the base without disturbing the wiring. Furnished in all standard voltages and also 30-60 volt combination. In ordering specify voltage.



"DELTABESTON"
Fixture Wire

A stranded wire, insulated with a tough, heavy wall of asbestos fibre.

Thoroughly impregnated to render the insulation moisture-proof.

Especially adapted for use in fixture wiring, where a flexible, heat-proof insulation is essential.

Prices quoted upon application.

Convention Headquarters

Central Elect

320-326 S. Fifth Ave. "The House

RAILWAY
ELECTRICAL ENGINEER

Official Journal
of the Association of Railway Electrical Engineers.

PUBLISHED MONTHLY BY

WRAY PUBLISHING CO.
EDWARD WRAY,
President.
C. D. SPERRY.
Assoc. Editor.
ADVERTISING BLDG.—123 W. MADISON ST.
CHICAGO.
Telephone, Randolph 7414.

Entered as second-class matter, August 6, 1909, at the Post Office at Chicago, Ill., under the Act of March 3, 1879.

TERMS OF SUBSCRIPTION
United States, Canada and Mexico - - - Per Year, $1.00
Foreign - - - - - - - - - - Per Year, $1.50

Table of Contents

Editorial:

The Open End Truck 189
Yard Lighting 189
Our New Presidents 190

Seventh Annual Convention A. R. E. E.:

Discussion of Papers and Com. Reports 191
The Wireless Telegraph & Telephone, By Dr. F. H. Milliner 194
Committee on Shop Practice 202
The Locomotive Headlight, By J. S. Minick 205
Manufacturers' Exhibits at A. R. E. E. Convention 205
Classification Yard Lighting 216
A. B. C. Car Light Course 218
The Railroad Electrician's Club 220
Prize Question Box 222
Practical Stunts 223

The Open End Truck

With the present Pullman standard six-wheel truck it very frequently becomes a serious problem to lay out the axle generator suspension so as to give proper clearance of the generator from roadbed and fish belly girder, and at the same time to provide sufficient clearance between the belt and the brake beam and truck sill. Frequently equipments are installed, where after juggling about for hours and obtaining a concession of slight increase or decrease in the length of brake hangers, etc., a compromise is finally arrived at whereby a clearance of ⅛ of an inch is obtained between belt and sill, and 3/16 of an inch between belt and brake beam. This kind of clearance is not clearance—it is interference.

Probably lack of belt clearance has been one of the greatest causes of car lighting belts being torn off and lost en route, and this has resulted in belt maintenance expense being one of the largest items in the cost of electric car lighting.

There are a great many open end trucks, both four and six-wheel, in service today, in which clasp brakes are employed, and there is neither end sill nor brake beam to interfere with belt operation. In the discussion of this subject at the recent A. R. E. E. Convention it was pointed out that approximately four times the average belt life is obtained from equipments mounted on open end trucks than that where equipments mounted on regulation trucks, with both end sill and brake beam to interfere with the belt operation.

With a car lighting belt consumption of nearly 2,000,000 ft. per year, representing an annual expense of approximately $1,000,000, it would then be possible to save over $700,000 per year in this one item alone, provided this change in the design of car trucks be made. This is a reform which the Association of Railway Electrical Engineers should prosecute vigorously, and with our committee on standards co-operating with the M. C. B. committee on train lighting much will undoubtedly be accomplished this next year.

Yard Lighting

The recent development of the high efficiency nitrogen filled mazda lamp has made it possible to now consider seriously the subject of providing adequate illumination in railroad classification, switching, freight and coach yards, and other large areas of railroad property. Heretofore the cost of installation and operation has been prohibitive, except in a few instances about large railroad terminals.

With the high candle power gas filled mazdas mounted sufficiently high and with efficient reflectors to provide uniform illumination, the item of operating expense comes within reason, and the next year will undoubtedly see great activity on the part of the railroads in this line.

Railroads are now beginning to appreciate more than ever before the importance of adequate illumination in the "Safety First" movement. Particularly in classification yards, where much of the work is done at night, and where low efficiency may mean low efficiency of the entire system, the advantage of an effective lighting system is probably more evident; but once the advantages of good illumination of large areas is proved in this case it will undoubtedly be extended to other branches of railroad equipment.

In discussing this subject at the recent A. R. E. E. Convention, Mr. Arthur J. Sweet, of Vaughan, Meyer & Sweet, referred to a comprehensive series of tests on the subject of street lighting. These tests showed that at a mounting height of 15 ft. or less, any unit which gives light more than 65 deg. from nadir (25 deg. below horizontal), produces a serious blinding effect, and requires a correspondingly higher illumination. Accordingly, either a 65 deg. screen angle for reflection or a higher mounting height is recommended.

At 36 ft. mounting height none of the units on the market today cause serious blinding effect. At lower mounting heights, however, they require a higher wattage, and more light to see the same thing. For instance, at a mounting height of 12 ft. an 18 candle power lamp in enclosed opal ball, which provides perfect diffusion, 75% more illumination is required in order to see an object clearly visible at normal illumination when the units are mounted sufficiently high. In other words, the mounting height of the lighting units is just as important a factor in the question of overall efficiency and effectiveness of the yard lighting system as is combined efficiency of the lamp and the reflector.

William F. Bauer

At the annual business meeting of the Railway Electrical Supply Manufacturers' Association, Mr. W. F. Bauer, Asst. Mgr. of the Railroad Department of the Edison Storage Battery Company, was elected President.

Mr. Bauer was Vice President of the Association last year, and for the past three years has been chairman of the exhibit committee. In this latter capacity he has done a great amount of work toward making the exhibit features of the annual conventions at Chicago a success.

"Billy" is one of the old original pioneers in the car lighting game. In the early days, around 1885, he played baseball, and was one of the stars of the Boston team. In 1899 he was electrician on the Pennsylvania R. R. and had charge of the first train lighting equipment on the Chicago Limited. An Eikmeyer dynamo with brotherhood engine was installed in the baggage car, and with suitable train line and storage batteries provided lights for the entire train. This system was designed by his father, then chief electrician of the Pullman Company at Chicago.

Wm. F. Bauer.

In 1891 he entered the Newark factory of the old Electric Accumulator Co., who at that time manufactured pasted type battery. He remained with this company until 1893, when he was employed in the Railway Department of the Westinghouse Electric & Mfg. Co. After his father's death, in 1895, he again went with the Pullman Co., and was appointed electrical foreman of the Waldo Ave. passenger yards in Jersey City. In 1897 he was train electrician of the Lake Shore Limited, being then in the employ of the Wagner Palace Car Co. He left this work in 1900 to accept a position as electric station foreman of the United Electric & Traction Co., at Baltimore, but the next year came back into the car lighting game with the Consolidated Ry. Elec. Ltg. & Equip. Co. While with this company he installed the first car lighting equipments on the Frisco Lines and the Missouri Pacific Railroad. In 1903 he was appointed chief electrician of the Missouri Pacific in charge of electric car lighting. In 1906 he came to Chicago as sales engineer of the Electric Storage Battery Co., and in 1908 joined the forces of the National Battery Co., which was later absorbed by the U. S. Light & Heating Co. For many years he was Western Manager of the U. S. Light & Heating Co., but in January, 1914, left this company to become Asst. Mgr. of the Railway Department of the Edison Storage Battery Co., which position he now holds.

H. C. Meloy

In the annual election of officers at the recent convention, Mr. H. C. Meloy, Supervisor of Electrical Appliances for the Lake Shore & Michigan Southern Railway Co., headquarters at Cleveland, Ohio, was elected president of the Association of Railway Electrical Engineers.

H. C. Meloy.

Mr. Meloy was born in 1866, and began his railroad experience in the mechanical department of the Pennsylvania R. R. at the Altoona shops of that company at the age of 16. For seven years Harry worked in all the various departments about the shop. He then was employed by the Union Switch & Signal Company for about a year. In 1888 he went to work for the Norfolk & Western, and here got his first experience in electrical work, being employed for about two years as electrician about the shop, installing on the road, etc. He then returned to the Pennsylvania R. R. and for about one year had charge of the erection of machinery in the Juniata shops. He then returned to the Norfolk & Western, and for seven years was foreman of electricians in connection with shop work. He then entered the employ of the Lake Shore & Michigan Southern Ry. as chief electrician in charge of power and lighting at Collinwood shops and also train lighting. In 1910 he was appointed supervisor of electrical appliances, having charge of all electrical equipment for power and lighting in railroad shops, terminals, docks, bridges, etc., and also train lighting over the entire system.

Mr. Meloy was one of the original eleven men who ment in Salt Lake City in 1907 and formed the nucleus of the association, which has grown into the present Association of Railway Electrical Engineers.

Mr. Meloy is an electrical man of wide experience, and one who has the best interests of the Association sincerely at heart.

Seventh Annual Convention A. R. E. E.

October 26-30, Hotel La Salle, Chicago

Discussion on Papers and Committee Reports

Opening Session

The convention opened at 10:30 a. m., October 27th, with the address of President Gilman, in which he called attention to the rapid growth of the association to date and showed the possibilities for future development.

The report of the secretary-treasurer was then received and referred to the auditing committee.

The report of the Committee on Reciprocal Relations, as published in the October issue of the Railway Electrical Engineer, was then read and accepted. Meeting adjourned.

Committee on Specifications for Wiring Crossings for Potentials Above 100 Volts.

The report of this committee, as published in the October number of the Railway Electrical Engineer, was then read by Mr. J. R. Sloan (Pennsylvania R. R.), chairman of the committee. Secretary Andreucetti stated that he had taken steps to have a conference between the committees of the various associations interested to examine specifications that are now being used and make necessary corrections in them. The committee was then continued, with instructions to report at a future meeting.

Tuesday P. M. Session

Committee on Data and Information.

The report of this committee, as published in the October number of the Railway Electrical Engineer, was then read by Mr. Edward Wray (Railway Electrical Engineer), chairman of the committee. In discussing the data on costs of electric car lighting, regarding the matter of thousand car mile versus car month basis of accounting Mr. H. C. Meloy (L. S. & M. S. Ry.), stated that the car month basis may give a very incorrect idea of actual costs, for where a car is in the shop for three or six months the charge on a monthly basis would be very low and greatly reduce the average cost for all cars. He stated that the only equitable basis of charging costs for car lighting was on a basis of service rendered. This is indicated only by the number of car miles operated, and no correct statement can be shown on simply the car month basis. Mr. Wray pointed out that from all the data received on car lighting costs there was only one railroad that submitted this on a basis of thousand car miles.

Mr. J. R. Sloan stated that the P. R. R. kept car lighting costs both ways. It is a very simple matter to do so, he said, and frequently shows, among other things, that the system which is the cheaper to operate per car month may be the more expensive per car mile. It all depends upon how the transportation department handles the cars. Mr. D. C. Wilson (Union Pacific R. R.), pointed out that the thousand car mile basis was the basis used for computing all locomotive and car repairs, and suggested that this basis be adopted for car lighting. It would, of course, be necessary to obtain the total monthly costs so the data would then be given on both bases as suggested by Mr. Sloan. Secretary Andreucetti pointed out that the association has already accepted a standard report blank for giving car lighting costs, and this blank, among other things, includes both the total monthly cost and cost per thousand car miles.

In discussing the data on shop motors Secretary Andreucetti stated that since the extensive installation of alternating motors on the C. & N. W. Ry. the motor maintenance expense has materially decreased and many troubles common to d. c. motors have been entirely eliminated.

Referring to the data on large size gantry cranes, Mr. Wray said that since writing the committee report it has been learned that one of these cranes of 150-ton capacity was installed in the Great Western shops for handling locomotives. The shop construction required that this crane be built as a gantry crane, supported from the floor, instead of a standard traveling crane, supported from the building columns. The crane is properly listed as a gantry crane, but as a matter of fact performs the functions of a standard traveling crane.

In discussing the committee recommendation for standardization for traveling cranes, Mr. T. V. Buckwalter (Pennsylvania R. R.) said that the data furnished by the committee conclusively shows the great need for such standardization. He stated that it would be possible to outline specific motor sizes for cranes so that the motors of one motor manufacturer can be interchangeably used with the motors of another motor manufacturer, so that the various railroads in purchasing a certain crane, which may have many good points, are not compelled to buy a certain make of motor, as is necessary in the present situation.

Such standardization as the committee recommends will enable the railroads to keep the same general type or make of motors in one group of shops and not have a large variety of makes in any one shop, as this always results in unsatisfactory and expensive maintenance. He stated that he believed motors could be standardized as regards mechanical outline and standards could be presented in such a manner that every motor manufacturer could compete on all crane business and the railroads would be able to purchase any particular crane and any type of motor they desired.

Mr. Wray stated that it would probably be possible to select three standard speeds for handling material with cranes, a slow, medium and high speed. The advantages of uniform standards for motor sizes would be threefold. The manufacturer would be able to supply motor equipment on cranes cheaper, railroad companies could purchase traveling cranes cheaper, and the maintenance cost and stock carried for emergency repairs would be greatly reduced. He stated that this is a very important matter, and one which should receive the best co-operation of both railroad men, motor manufacturers and crane manufacturers, and all of these interests should be represented on this committee.

President Gilman referred to the methods adopted by this committee in securing the great amount of information presented and stated that the success of the committee in this respect was largely due to the thoroughness and care with which the tabulated information blank submitted to motive power officials was prepared. The report of the committee was then accepted.

Kaufmann, Weimar & Fabry Co., Chicago, Photographers

Dinner Dance of the Seventh Annual Convention of the A. R. E. E.

Committee on Standards.

The report of this committee, as published in the October number of the Railway Electrical Engineer, was then read by Mr. D. J. Cartwright (L. V. R. R.), chairman. In discussing the matter of the taper fit of the generator pulley on the shaft, Mr. Cartwright stated that the recommendation of the committee of ¾ in. in 12 means the total taper, both sides. Mr. W. L. Bliss (U. S. L. & H. Co.) called attention to the two holes in the web of the pulley, these being tapped for the application of the pulley puller. He said that since these threads will be subject to corrosion and collection of dirt they should be threaded with an oversized tap instead of a standard tap.

Mr. J. R. Sloan called attention to the two holes in the web recommended for pulley puller, and stated that it had been found best practice on the Pennsylvania Railroad to use a slot with a T-head bolt on the pulley puller, simply inserting the bolt and giving it a 90 degree turn performs the same function as screwing in the nipples of the pulley puller. It is also a much less expensive job of manufacturing, as it does not require drilling or tapping. Mr. Sloan also stated that inasmuch as a standard taper of 1½-in. in 12 total had been adopted by the Association in 1913 for car lighting generators equipped with ball bearings, the recommendation of the committee at this time specifying ¾ of an inch taper, is accordingly reversing this standard already adopted. He further stated that with a 1½ in. taper and 4 in. hub, the diameter of the shaft is larger at the inside of the hub than the dimensions recommended by the committee. Accordingly, we get greater strength at this point, which is very much needed.

There was much discussion pro and con as to the advantages of the ¾ in. and 1½ in. taper, but it was finally decided that inasmuch as standards for pulleys for ball bearing generators had been already adopted by the Association, that this part of the present committee report be withdrawn The report of the committee as so amended was then accepted and will be submitted for letter ballot. Upon motion the meeting adjourned.

Wednesday A. M. Session

Committee on Electric Headlights.

The report of this committee, as published in the October number of the Railway Electrical Engineer, was then read by Mr. George E. Murray (C. & N. W. Ry.). In discussing the subject of generator voltage Mr. Murray called attention to the desirability of having a standard operating voltage. He stated that some roads are using 40 volts, some 35, some 32 and some roads as low as 6 volts. On the matter of wiring installation, Mr. Murray stated that weatherproof wire seemed to stand up even better than rubber covered wire. On the other hand, unless the weatherproof wire is covered with a protective coating on the outside, the tar composition of the insulation melts under the excessive heat and causes the wire to stick to the inside of the conduit, so that it is practically impossible to withdraw it after it has been in service six months or a year. Mr. Gardner (C. B. & Q. R. R.) stated that they use high grade rubber covered wire exclusively and seem to have no trouble with excessive heat. He stated that continuous service is the all important consideration and the best equipment obtainable should be installed.

Dinner Dance of the Seventh Annual Convention of the A. R. E. E.

President Gilman stated that they had experienced no trouble with rubber covered wire in conduit on locomotives, although he called attention to the fact that all the wiring inside of the cab was installed either in circular loom or molding.

As to voltage, Mr. Gardner stated that they originally operated their equipment at 32 volts, but that lamp burnouts were excessive, due to poor regulation and also to the fact that the headlight men would speed up the turbine a little so as to get more light. A 40 volt lamp was then used, but it was found that this gave such poor light that a compromise of 35 volt lamps was decided upon.

Mr. D. J. Cartwright (L. V. R. R.) suggested that a voltage of 32 volts be adopted for headlights, as has been done for car lighting; this would make it then possible in case of a turbine failure to get emergency light from the car lighting equipment. Mr. J. L. Minick (Penn. R. R.) referred to the work of the headlight committee of the American Ry. Master Mechanics' Association. This committee made a very elaborate series of tests and the subject was reported at Atlantic City last June. Upon motion it was decided to continue this headlight committee, with instructions to confer with the headlight committee of the American Ry. Master Mechanics' Association, with a view to standardizing methods of photometry voltage and candle power, and at the same time, to co-operate with the lamp committee of A. R. E. E., with regard to the standardization of lamps.

Mr. Minick pointed out that the master mechanics' tests referred to showed that the arc lamp itself has inherently bad regulation; the arc voltage may vary as much as 30 to 40%, even when operated from a storage battery. These tests also showed that an incandescent lamp giving a projected beam power of 1/10 that of the arc or sufficient to enable the engine man to see an object the same distance down the track. This is due largely to the fact that light in the arc lamp predominates in blue and although blue will register on the photometer, it will not show up in the form of reflected light from objects on the track.

He called attention to the vast number of small automobile lighting sets operating at 6 volts. He stated that it should be entirely feasible to provide a generator of about twice the capacity, which might have the same characteristics both as to voltage control and automatic operation. Mr. C. W. Bender (Nat'l Lamp Wks.) stated that at the present time there are over 2,000,000 6-volt headlight lamps sold per year for automobile service. At the present time the highest candle power made is 165 c.p. The filament for this lamp is very heavy, strong and rugged and will withstand the most severe service. From the discussion it appeared that 6-volt headlight generators would soon be on the market.

Mr. Murray stated that the C. & N. W. Ry. are now testing out some 300 c.p. 30-volt lamps, most of them having been in service over a month with wonderful success, there having been no failures whatever. He called attention, however, to the requirements of certain states where the law specified an unreflected candle power of 1,200 to 1,500 c.p. Mr. Minick stated that none of the headlight equipments on the market today actually meet this specification. Mr. Minick also called attention to the fact that during the master mechanics' tests a 600-candle-power incandescent light in a properly designed reflector produced exactly the same photometric conditions of lighting as an arc lamp taking something over 1,000 watts. He stated that a beam candle power of 10,000 c.p. seemed to be about the maximum and should be employed. Headlights of a higher candle power give serious trouble with phantom signals, etc.

In discussing the relative advantages of the 32-volt versus the 6-volt lamp, Mr. Rollinson (Westinghouse Lamp Co.) stated that it was quite possible to make either lamps in ordinary candle powers. In the lamps of higher candle power it is probably easier to make the 32-volt lamp than it is a 6-volt lamp. On the other hand, the smaller candle power lamps of from 40 to 60 c.p. will be more efficient at 6 volts than at 32. He stated that if any railroad wanted a 1,200-candle-power 32-volt lamp this could be supplied, but this would, of course, be an experimental lamp and short life might be expected at first.

Upon motion the report of the committee was accepted.

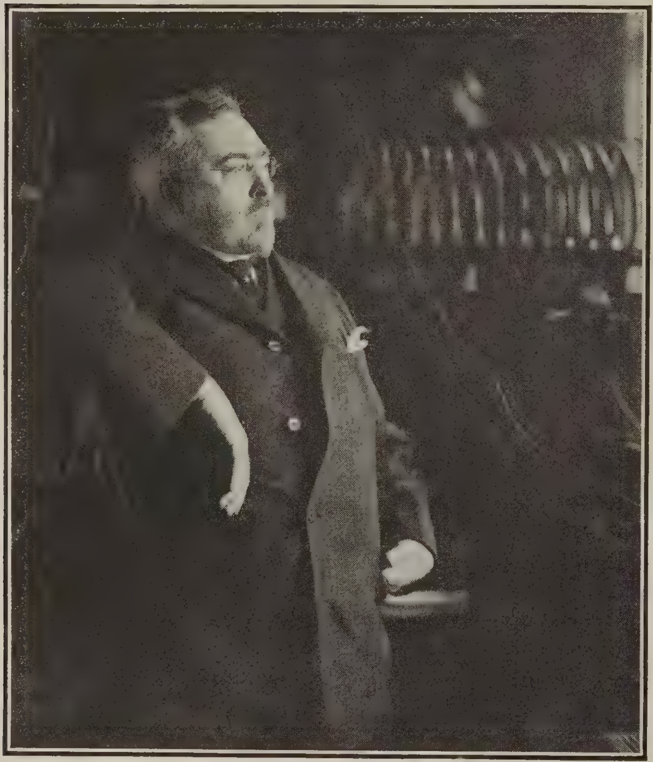
President Gilman then introduced Dr. Frederick H. Millener, who presented a paper as follows:

Wireless Telephone and Telegraph

As an Adjunct in the Operation of a Railroad

By Frederick Millener

Mr. President and Gentlemen, I have had the honor of being asked to come to this great meeting, and to try to tell you what we have been doing on the Union Pacific Railroad in the line of communication between trains, and between stations and trains, by wireless telegraph, wireless telephone, and by wire.



Dr. Frederick Millener

The commodity most in demand in the world today, and that which the world will pay the highest for, is speed. The second is safety, as safety lowers the price to be paid for speed, and any instrument or thing which will add to these two great commodities, must have a value to mankind, therefore, this is my excuse for being present this morning.

Few of us realize the rapidity of the changes and improvements which are taking place around us. Little over half a century has elapsed since the close of the Civil War, and yet never in the world's history has there been so great a change in a like period of time in the social, military, civil and mechanical customs of the world, and this country in particular.

Some investigator announces to the world a successful laboratory experiment, the next decade or so sees it indispensably connected with our commercial life, and wonder is expressed that we were able to do without it before. Thus it is with the wireless.

I wish to call attention this morning to the difference between a laboratory experiment and one which has been worked out in detail and perfected. The inventor announces his discovery because, of course, he wishes as much credit as is due him, for, unfortunately, in this country, many times that is all he gets out of it. So, in wireless, the child has thus been taken for the man.

For at least a century before an electric impulse, representing a signal, had actually been transmitted and received without intervening and connecting wire coupling, the subject was a favorite one with the physicist, and it is not unlikely that the ancient Greeks who witnessed Thale's experiment of transferring energy from amber to neutral paper, dreamed of the bridging of greater distances by the same wonderful influence.

The first recorded instance, however, in which a definite scheme was proposed having for its object the telegraphing without wires by electricity, was that given by Silva, a Spanish physicist who read a paper "On the Application of Electricity to Telegraphy" before the Academy of Sciences on December 16, 1785, at Barcelona. He advocated that a given area of earth be positively electrified at Mellorca and that a similar area of earth be charged to the opposite sign Alicante; the sea connecting these two cities would then act as a conductor when the electric difference of potential would be restored and by a proper translating device the transfer of energy could be indicated.

But the greatest benefit of wireless investigation has come as the result of the telegraph and telephone, the invention of the telephone receiver by Alex Graham Bell, the researches of Hertz, Marconi, Braun, Slaby, Arco, Fessenden DeForest and others, all have furnished their contribution to what is now known as the wireless.

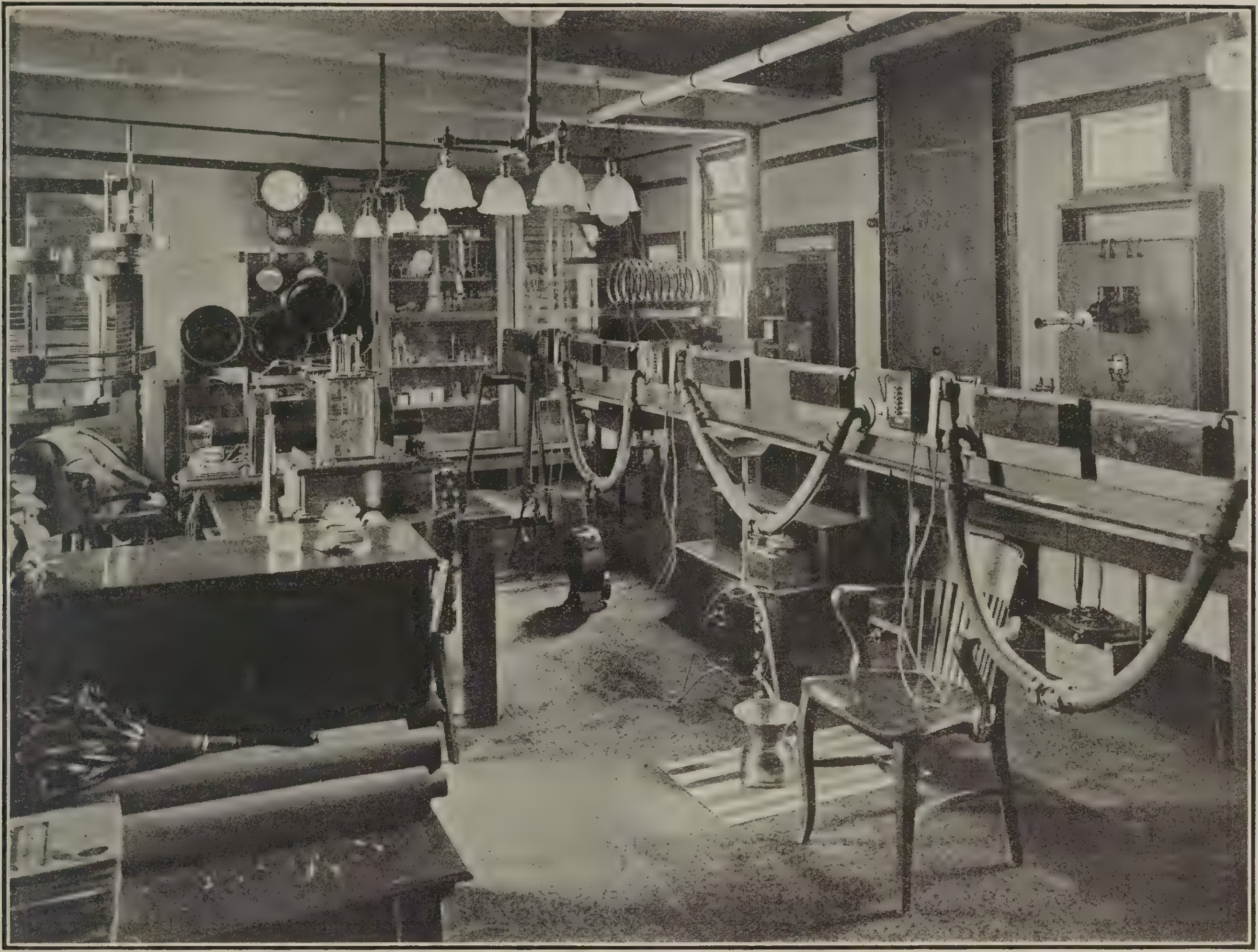
At this point it might be interesting to note that in 1857 a telegraph superintendent in France outlined in L'Illustration, a French paper, a complete description of a telephone, which, however, he did not follow up. The French Government recently, however, in recognition of this fact, made Bourselle a member of the Legion of Honor.

I purpose to explain in part a new departure or field for the wireless, or, at least, the researches which I have had the honor of conducting for the Union Pacific Railroad.

Wireless Signals

The Coherer.

In 1906 the Union Pacific Railroad management ordered me to devote my time to finding a method of signaling the cab of a locomotive or communicating with a train without interfering in any manner, or placing any obstruction along the right of way. For this purpose the services of a storage battery electric truck were utilized. The machine weighed 5,500 pounds, with the batteries in place, and was made of iron and steel and ran around the shop yards on a narrow gauge track. The car was built by the Westinghouse Electric Manufacturing Company and power was developed by a series wound motor. The car was equipped with an aerial or antenna, and many and thorough experiments were tried with it. The car was caused to back and move forward at four different speeds, ring a bell, etc., at the will of the person at the wireless key. Antennae were placed on buildings, along side the track various methods were used to receive the impulse on the car and transform it into mechanical motion; the practical application of this experiment lay in the fact that the iron and steel car was a capacity in itself and therefore it did not make any difference whether we had a good ground connection or not, as the car would work just as well when it was insulated from the ground as when connected directly by wire. This electric truck has been very valuable for experimental purposes, because it had 186 volts direct current and plenty of power. However, on a railroad, a danger signal must operate at least 100,000 times in succession without a failure, and must not be operated by any other means than the means intended and as the lighting of an arc light or atmospheric disturbances will sometimes throw the signal, and as the best coherer or valve detector will not last for anything like 100,000 operations without a failure, we therefore discontinued work on the mechanical wireless cab signal, although no difficulty presented itself which could not be overcome, except that it was not reliable. This was one of the earlier reasons why the coherer was displaced in wireless telegraphy as a detector and the telephone and other instruments substituted.



Laboratory Model of Train of Four Cars Connected Together by Wire Connections Inside the Air Hose

Wireless Telegraph

Before proceeding I should state that the West is a country of magnificent distances. People think nothing of coming to Omaha from places two, three, four, six and even eight hundred miles away for provisions, entertainment, etc. Such a country develops its population on the same broad lines. For miles and miles there are no trees, and you can frequently see along the track a long line of telegraph poles which have been put out of business by ice and a heavy wind storm.

So it seemed that in such a country as that there might be a chance for the wireless.

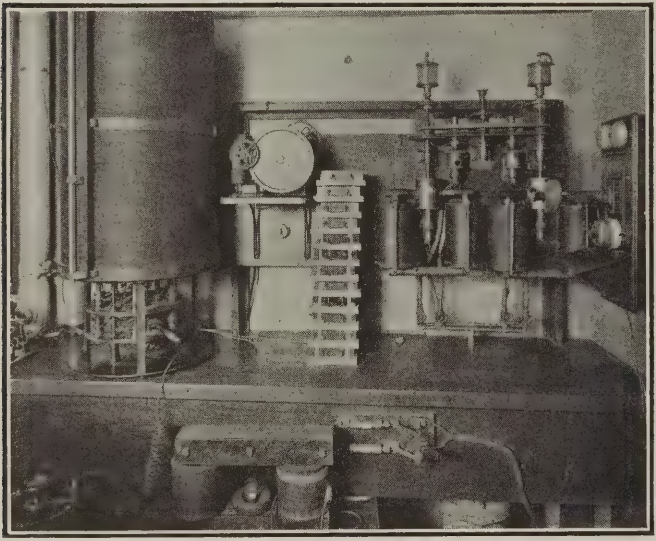
The next work, I therefore undertook, was wireless telegraph between stations. Although the wireless has taken its proper place at sea and the work done very interesting, instructive and practical, wireless telegraphy has not been exploited on land to the same extent, principally because there has been no demand for it, the wire telegraph and telephone apparently fulfilling all that was required.

When Samuel F. B. Morse in 1844 invented the telegraph, he built, if you remember, the first line a distance of 40 miles, from Baltimore to Washington, and the privilege of sending the first telegraphic message was given to his friend, Miss Annie G. Ellsworth. That first message ever sent over the wires read:

"What hath God wrought."

If it was appropriate at that time to send those words, how much more appropriate is it today, when we telegraph and telephone without wires through limitless space, to say:

"What Hath God Wrought."



Wireless Telephone Generating Apparatus

For 600 miles west of Omaha the country is comparatively level and straight. The elevation at Omaha is 1,200 feet, gradually rising until an elevation of 8,000 feet is reached at the summit of Sherman Hill, Wyoming. In planning for wireless telegraph stations this elevation must be taken into consideration.

Another thing which enters very closely into the consideration of the subject is static electricity. In summer the static electricity between Green River, and Cheyenne, Wyoming, and Sherman Hill, Wyoming, causes all sorts of disturbances with block signals, burning them out, and occasionally putting the wire telegraph out of commission, therefore, as a result of experiment, it was decided that the induction coil method of generating wireless impulses, or waves of the 60 cycle alternating current variety would not be satisfactory, for even if nine messages out of ten were received properly and the tenth not so, fate would in all probability make that message the most important one. Various schemes were tried but it was found that the best results could only be secured by using a higher frequency than 60 cycles. Another fact which enters into the consideration of wireless stations in the West is the absence of direct current. All electric installations, being comparatively new, are alternating current, and of the latest design. It, therefore, appears that if 60 cycles could be used, it would materially cheapen the installation and for very small intermediate stations, it can be used, but not where static electricity is prevalent or usual as the musical note in the receiver is so low that it is confused with the atmospheric or static electricity. However, for the stations at North Platte, Nebraska, Green River and Cheyenne, Wyoming, it was planned to use a frequency of about 550 cycles transformed up to about 12,000 volts in an open core transformer, with a 5 K. W. generator at Cheyenne and a 5 K. W. at North Platte, and a 10 K. W. at Green River. The station at Cheyenne is to work at all times day or night at least as far East as Omaha, and we hope an equal distance the other side of the mountains. The four stations, Omaha, North Platte, Cheyenne, and Green River, will thus work together at all times, and in all conditions of weather. In the telephone receiver the message from a high cycle high frequency station is a high pitched note, similar in character to the sound of a tuning fork at 1,020 vibrations per second and is much pleasanter to listen to than the old 60 cycle low note. The sound also being high in pitch is not confused with static electricity; thus one of the greatest difficulties of the earlier wireless investigators is done away with.

Receiving Message by Radiophone Receiver—No Wires to Ground

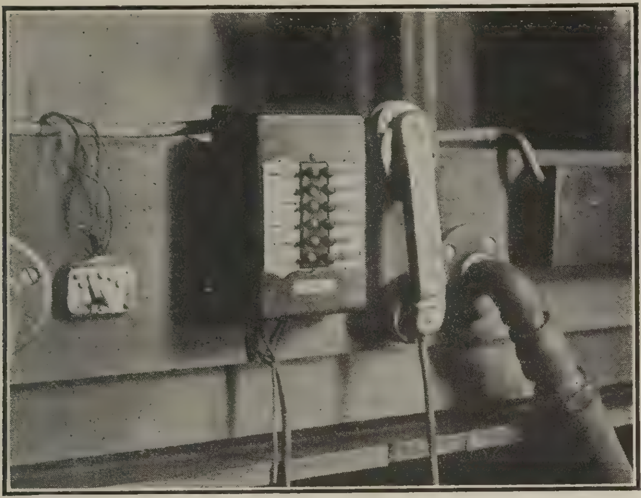
Aerials or Antennae.

In railroad work it is absolutely necessary to have your antennae close and compact. In the first installation of the wireless telegraph station it is important not to complicate matters. Make the antenna simple and easy to repair; endeavor to utilize men in the employ of the railroad and not import experts, as this will only cause trouble, fault finding and dissatisfaction. The work is not so difficult but what the average person can understand it if properly explained and it is only mysterious because it is new.

I do not mean that to be a reflection on the employment of expert assistance, but if we put stations out in the country where it is difficult to get good men and keep them, and do not educate our own men who own property and are assisting in the development of the country it will have a tendency to breed discontent. It has been, and is the policy of the Union Pacific, through its Educational Department, to carry out this plan.

We have to have experts, but we do not have to have an expert at every station who knows more about it than the man who installs the plant.

The present tendency is toward using complicated apparatus. This is not necessary; the simpler the better. It had been found that the use of the flat top ships antenna is more practical than the umbrella type at stations, and parallel to the track, elevated by two self sustaining towers, the height of which should be at least 210 feet and should be constructed to stand a wind stress of 90 miles per hour, at least, as we are building the wireless to work, when the wires go down. The umbrella antenna requires too many guy wires and at the critical moment falls down from wind, snow and ice. It is also difficult to repair in the yards or at stations as it would take up too much room. The flat top or ships antenna—if it becomes covered with ice—can be quickly lowered, repaired and raised by four men who are not necessarily skilled help. The wireless stations should be close to the train despatcher's office, for if the storm destroys the telegraph wires, it may wreck the local telephone outfit.


Interphone Equipment for Each Car—The Buttons are Labeled on the Front of the Switch Box as Baggage, Diner, Pullman, Pullman, Observation, Long Distance and Wireless

The flat aerial may be rendered somewhat directional by the position in which it stands and where the wires lead into the station. Another reason for getting closer to the tracks is that the wireless wave will be rendered directional by the tracks and will travel farther with the rails than in other directions, or in other words, the signals may be rendered more intense east or west as desired. It frequently happens that a wireless message seems to travel up a stream of water or where there are metallic conductors much better than the same distance over plains or wooded country. A person is almost led to believe that buildings, trees, fields, etc., act on the wireless wave as the damp pedal of the piano acts on the vibrating musical cords, thus grounding the waves.

The principal objection to the flat top aerial is its cost as it requires two towers to support it instead of one.

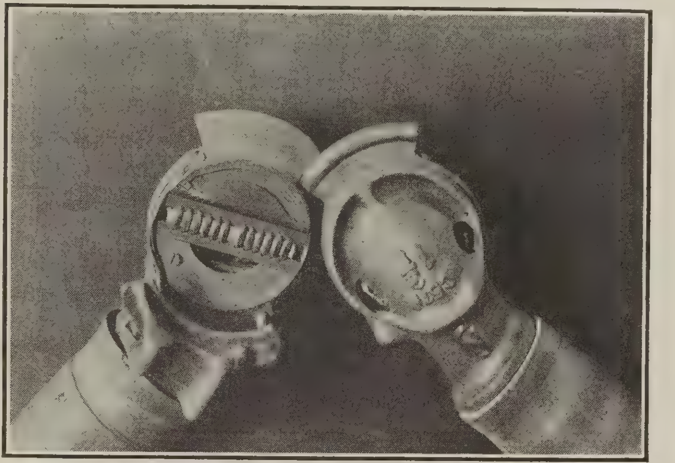
Apparatus.

One of the first real difficulties met with in wireless telegraph work is the selection of proper apparatus. Each firm or system will exhibit patents which appear to cover all they claim, in fact, gives them a monopoly of the ether. However, this is being rapidly attended to as the Marconi Wireless Telegraph Company is in litigation with several American companies at present, and it will possibly have a certain amount of influence in cleaning up the patent situation.

What I particularly wish to call your attention to in the above statement is that about the time Alexander Graham Bell was working in the telephone field there were numberless improvements and patents and endless litigation, and finally there had to be a great trial and the decision of the United States Supreme Court settled the matter. Then capital took hold and we had the beginning of the system that we have today.

In England the court room has been converted into a wireless station for the purpose of properly explaining this subject, which mathematically can be made to appear so difficult.

In England at the present time the wireless telegraph is operated in connection with the post office. For more than three years we have been ready to install a wireless telegraph equipment on the Union Pacific Railroad, but for various reasons, not connected with the wireless, it has been postponed. In the meantime, I have turned my attention to other work, the development of a wireless telephone.


Car Coupling for Composite Wire and Wireless Telephone

The Wireless Telephone

In March, 1911, I read a paper before the New York Railroad Club on the Wireless Telegraph, and the Railroad, and about one week before going to New York I had completed my first wireless telephone; that is, I had made it talk. Since then I have continued work on this apparatus, and, I believe, have now placed it beyond the mere experimental stage. The apparatus is designed to be a composite telephone; by that I mean we are going to talk by wireless, and, using part of the same apparatus, talk by wire. In other words, the machine is an intercommunicating telephone from car to car, a long distance wire telephone when the train is stopped at a station, and when the train is in motion between stations, a wireless telephone by means of which we talk to the train ahead, the train behind, or the station. The device is so arranged that while talking from car to car it is selective talking and selective signalling. While talking long distance by wire, only one person can talk from the train at a time, and the train is connected to the city trunks. On leaving the station, from any car you can call the baggage car, requesting them to start the wireless generator.

As soon as that is done, the party can commence to talk. The distance which the message travels is the distance from the aerials on the train to the wire telegraph lines alongside the track. A pair of these wires have been balanced up and equipped with condensers around the telegraph instruments, and are used as an antenna.

Four years ago in my talk in New York City I described a means by which these messages could be received, and I had arranged a very simple one. You must know that at times people have to be shown, and sometimes they believe that you are endeavoring to deceive them, using concealed wires, or something of that sort, so in order to have their minds free, I equipped an umbrella with a tuning apparatus and allowed them to walk wherever they pleased around the shop yards, and we talked to them by wireless telephone.

I noticed, two years later in the "Scientific American," that people a few miles from the Eiffel Tower, Paris, France, by means of a similar device, were able to receive the time signals, the ribs of the umbrella acting as the antenna or aerial capacity, and their feet and body the ground connections.

In an issue of the "Scientific American," October 24th, 1914, I find the following article:

"Wireless" Automobile Top in War.

"A report from Belgium by the correspondent of an English automobile trade journal tells of a most extraordinary use of an automobile top. It seems that a British patrol succeeded in capturing a German touring car in which two officers were seated. The motor had broken down and the officers were made prisoners of war. In glancing over the car one of the patrol noticed a wire connection to the 'skeleton' of the raised top. Following the wire he pulled from under the seat a telephone receiver and, holding it to his ear, was dumbfounded when he could plainly hear a message coming from nowhere in particular. The top-skeleton formed the receiving wires of a wireless telephone station, and the message came from the nearest headuarters of the army corps to which the officers belonged."

Discussion

In discussing the paper Dr. Millener stated that several railroads are at the present time working on this subject, both from an original point of view and otherwise, and predicted that within the next five or six years much will be accomplished. He described a loud speaking telephone installation in the Union Station, Omaha, and by using part of his wireless telephone equipment in connection with the apparatus regularly installed, he obtained most satisfactory results. On one occasion the Doctor took a phonograph to the depot and put on "Onward Christian Soldiers"—it sounded as if a new pipe organ had just been installed in the depot. He thought much could be accomplished in improving the present installations for announcing trains by telephone in New York and Pittsburgh.

Upon being asked whether it was possible to equip a freight train with wireless telephone, Dr. Millener said that the Union Pacific had done some experimenting with a copper wire connection woven in the air hose between cars. This would make it possible to install a direct metallic circuit, using ground connections at either end. As to wireless equipment for this purpose, he said that this had never been tried up to the present time, but could easily be accomplished, although some experimenting would have to be done in amplifying the sound so that the engineer would have no trouble in hearing it. A vote of thanks was extended to Dr. Millener for his excellent paper. The meeting then adjourned.

Wednesday P. M. Session

Committee on Industrial Trucks.

The report of this committee, as published in the October number of the Railway Electrical Engineer, was then read by Mr. T. V. Buckwalter (Pa. R. R.), chairman. In discussing this report Mr. Buckwalter stated that this committee had co-operated with a similar committee of the Society of Automobile Engineers and had held several joint meetings. The report as presented was practically adopted by the committee of automobile engineers with a few slight modifications.

As to the possibilities of standardizing on length and turning radius of trucks, Mr. Buckwalter stated that the committee did not take up this matter, as there is such a wide diversity of outline among the various manufacturers that the committee did not feel it was possible to standardize on truck outline. As to the turning radius, however, he thought something might be done. He stated that the truck outline is controlled almost entirely by the conditions under which that truck is going to operate.

Mr. W. L. Bliss (U. S. L. & H. Co.), in discussing the matter of battery voltage for trucks stated that it seemed to be largely a question between 24 and 36 volts. He pointed out the advisability of using the latter voltage both on account of the fact that it is standard for car lighting, and also because of the readiness with which the 16 cells can be divided up in quarters, halves, eighths, etc. He stated that 12 cells was not quite so handy to juggle as is 16. Mr. Buckwalter stated that on the other hand number 12 is even more convenient than 16, as it permits of the use of 2, 3, 4, or 6 cells in a row. He stated that for 24-volt service 12 cells of lead battery and 21 cells of Edison battery were used on the Pennsylvania, although some users employ 20 cells of Edison battery. He pointed out that the majority of trucks in service are operated at 24 volts. Three 12-cell batteries in series can be conveniently charged on 112 volts, whereas this would be impossible with 32-volt cells. Upon motion by Mr. Buckwalter, it was decided that the following standards be adopted for industrial trucks and be referred to letter ballot:

The capacity shall not exceed 4,000 lbs.; the truck shall operate at a standard speed of five miles an hour, loaded for general service, with an alternative speed of seven miles per hour, loaded for operation under special conditions when runways are comparatively long and free from other workmen; the voltage of the truck shall be 24 volts and a battery consisting of 12 cells of lead battery with jar sizes 5 13/16 by 6 3/16 with a high bridge and 5/32; wall and for the Edison battery, 21 A-6 cells assembled in three trays of seven cells each; all tire equipment shall be pressed on tight, detached tire cross section, including base, not to exceed 2-in. width; the wheel rim shall not be less than width of the tire and the following wheel diameters: 10, 16, 20, 22 and 27 ins., with corresponding diameters of rims, as outlined in the report, with a possible tolerance from the rim diameter of minus zero and plus .005 in. Motion was carried.

In discussing the subject of tire standards, Mr. Howard (B. F. Goodrich Co.) stated that with these five tire sizes standardized it will now be possible to carry complete stocks in branches and tire depots, which heretofore has been impossible on account of the great ranges in tire sizes. For instance, his company alone has at the present time over 20 different sizes of moulds for various tire sizes for industrial trucks. He stated, however, that the various sizes now being furnished would continue to be supplied as long as there was a demand for them.

Committee on Electric Traction.

The report of this committee, as published in the October number of the Railway Electrical Engineer, was then read by Mr. J. R. Sloan (Penn. R. R.). In discussing this report Mr. L. R. Pomery (U. S. L. & H. Co.) stated, owing to a lack of capacity in the New Haven power station at Stamford, Conn., the New Haven has made arrangements with the Edison company for the purchase of power for operating trains between Stamford and New Haven, Conn. He called attention to the large number of railroad electrifications operated at the present time, power for which is purchased from a local central station. Upon motion the report of the committee was received.

In a communication submitted by Mr. C. H. Quinn, Chief Electrical Engineer of the Norfolk & Western, attention was called to the fact that there is a slight error in this report, in that the electric locomotives for the Norfolk & Western Ry. consist of 2 half units of 130 tons each, or a total of 20 tons per locomotive. These half units are identical, and are never to be operated singly, so the locomotive should be rated as 260 tons instead of 130.

Committee on Wire and Cable Specifications.

The report of this committee, as published in the October number of the Railway Electrical Engineer, was then read by Mr. Azel Ames (Kerite Ins. Wire & Cable Co.), chairman. This specification being almost identical with that submitted by the committee last year, there was practically no discussion. Upon motion the report of the committee was received.

Thursday A. M. Session

Committee on Axle Lighting Equipment.

Before reading the report of the committee Mr. H. R. Bucks (Oreg. S. L.), chairman, made a few remarks and referred to Fig. 9, page 135, and stated that the scale of ordinates had been omitted from the curves at the top. These should be $25, $50 and $75 respectively, being the cost per coach per annum. Tables 2 and 3 should precede Fig. 9, and do not refer to the paragraph on axle equipment in England.

Mr. Bucks then read the report of the commtitee, as published in the October number of the Railway Electrical Engineer. In discussing this report, President Gilman referred to the fact that the data presented shows that the maintenance of dynamos is considerably greater than that of storage batteries. Mr. Bucks stated that some of the figures presented include the cost of belting with that of dynamo maintenance, but said there were other statements presented which do show that the cost of dynamo maintenance alone is greater than that of the batteries. In reply to a question as to whether these figures include interest and depreciation on investment, Mr. Bucks stated that they include only actual operating costs, labor, material and supervision. Mr. Cartwright (L. V. R. R.) emphasized the importance of differentiating between maintenance cost and operating cost; the latter should include interest, depreciation and supervision, in addition to maintenance costs, which include only labor and material.

Mr. L. R. Pomeroy (U. S. L. & H. Co.) suggested that logarithmic ordinates be employed in plotting curves shown in Fig. 8. This would then separate the curves shown at the bottom of the diagram so that the variation would be more readily observed. He offered to re-draw this curve on this basis.

In discussing the matter of high maintenance cost of dynamos, Mr. Colegrove (Ill. Cent. R. R.) stated that this was undoubtedly due to the fact that dynamos require more supervision and inspection than do storage batteries. Mr. L. S. Billau (B. & O.) confirmed Mr. Colegrove's statement and stated that he had made an analysis of that situation on the departure basis, these figures indicating an expense of from 25 to 90 cents per car departure for purely terminal labor. He pointed out that the storage batteries do not require the same daily inspection that the generator does and if it were possible to sub-divide further the costs between maintenance and inspection, the dynamos would undoubtedly show a lower maintenance expense than the generators. President Gilman referred to the fact that the report mentions the successful use of glass jars for storage batteries in England. He also mentioned the fact that one manufacturer in this country has placed on the market heavy vitrified clay twin cell tanks. Mr. Colegrove stated that there are two sets of these stone-ware jars in service on the Illinois Central and the battery men seem to think very favorably of them. He mentioned a derailment which occurred recently on one of these cars, in which the car went over on its side and the battery box was half buried in mud. There was no breakage from the accident.

Mr. Bucks, chairman of the committee, mentioned the recent application of a new belt drive for car lighting generators, known as the Peerless V-belt, consisting of a steel chain, over each link of which is placed a V-shaped housing with a small piece of friction canvas on each. This chain drives in V-shaped pulleys and does not require any initial tension on the belt to deliver full load capacity. Mr. Colegrove (Ill. Cent. R. R.) stated that they have one in use on their road with apparent success and stated that the Pullman Co. have some of these belts operating successfully on six wheel trucks, the latter requiring the use of an idler on the end sill. He also stated if the manufacturers of trucks could be prevailed upon to design a truck for the axle generator, omitting the brake beam and possibly the end sill of the truck, much better results could be obtained with all types of belts, particularly with the V-belt. Mr. S. W. Everett (A. T. & S. F. Ry.) stated that this V-belt, although a radical departure from all other types, should be very carefully tried out by all car lighting men.

Mr. Colegrove stated that belt costs on open end and other types of trucks had been segregated and it was found that belt averages on the open end truck would run very close to the 100,000-mile mark, but on the standard type truck would average 25,000 miles or less. He stated that most of the belt losses seemed to be caused by lack of proper clearance. Mr. W. L. Bliss (U. S. L. & H. Co.) stated that one of the most serious problems in the operation and design of axle equipments has been the matter of proper clearance. He stated that this is a matter which the Association ought to take up and prosecute vigorously to see if some kind of reform cannot be inaugurated in truck and underframe design. President Gilman stated that this subject will be given very thorough consideration by the committee on standards during the coming year. The report of the Committee on Axle Equipment was then accepted and the committee thanked for its thoroughness in preparing such a valuable report.

Committee on Head-end Equipment.

The report of this committee, as published in the October number of the Railway Electrical Engineer, was then read by Mr. K. R. Hare (N. P. Ry. Co.), chairman. Mr. Anderson (Pa. R. R.) referred to the mention of current being available for lighting, heating, cooking, refrigeration, etc., and asked if this system had been actually employed for ventilating and refrigerating cars en route. Mr. Hare stated that up to the present time they had not done this on the passenger trains, but the matter has been seriously considered for placing one of these machines on one car of a freight train and have a motor-driven refrigerating apparatus on each of the refrigerator cars throughout the train. With the cars and materials thoroughly pre-cooled before leaving the terminals, this equipment could undoubtedly be operated to provide refrigeration for trains en route from Portland to St. Paul and considerable saving in ice effected. Mr. E. S. MacNab (Union Pac. Ry.) asked if any trouble had been experienced with ice and snow in cold weather, due to the fact that such a large hole is made in the floor of the baggage car. Mr. Hare stated that a loose covering of asbestos is provided between the top of the base mounting of the generator and the floor of the car. The machine is free to move with the truck, yet all cold air, snow, etc., are excluded from the car. Mr. H. R. Bucks pointed out that the test of a steam-driven turbine, showing 160 lbs. per k. w. hour was taken for about half load on a 25 k. w. machine, and stated a better economy would be provided with a machine of a smaller capacity and suggested that a comparison be made between 15 k. w. axle generator and a 15 k. w. steam turbo generator. Mr. Hare, however, pointed out that the figures are not made on any theoretical basis, but are actual costs on the Northern Pacific.

Mr. L. S. Billau (B. & O. R. R.) stated that a few years ago they conducted a series of road tests to ascertain the fuel consumption of the headend system as compared with the axle generator system and was surprised to find that the axle generator equipment seemed to consume about as much coal as the headend system. This was undoubtedly due to the power lost in regulators, needless overcharge to the battery, etc.

Mr. S. W. Everett stated that the testing department of the Santa Fe had carefully investigated the subject of power required for driving axle equipment and had come to the conclusion so much of the power is taken by the axle equipment when the train is coasting, slowing down, etc., that a definite charge can hardly be made. In fact, it is considered on that road that the axle equipments do not require any power. Mr. H. R. Bucks called attention to the fact that the headend system had operated successfully on Western roads and had been apparently unsuccessful on the Eastern roads with the single exception of the B. & O. He stated, however, that even with a road thoroughly equipped for headend lighting, it is often difficult to prevent a light failure. Mr. Pomeroy called attention to the severe conditions under which steam turbines on baggage cars are compelled to operate, wherein the excessive condensation in unprotected pipe lines through one or two cars ahead of the baggage car, compels the turbine to operate more as an hydraulic turbine than a steam turbine.

Mr. W. L. Bliss called attention to the fact that the statement in the report to the effect that the present installation is the first axle equipment design to light an entire train is hardly correct. In 1904 his company designed and built an axle generator which was installed on a locomotive tender on the Penn. R. R. The machine was built as a street railway motor, gear-driven, and lighted two of the best trains of the Pennsylvania successfully for several months. The scheme was ultimately abandoned, however, because of the difficulty of keeping the trains equipped with train lights, batteries, regulators, etc., and in preventing foreign cars from getting into the train. He stated that the headend axle-driven system was undoubtedly perfectly feasible and proper, and should be the most efficient kind of a lighting scheme that can be developed on a railroad train. It centralizes power and should accordingly be both more efficient in its operation and require less maintenance attention than a number of small machines distributed throughout the entire train. He called attention to the fact, however, that in order for the system to be really successful a sufficient number of baggage cars or locomotives must be equipped or there will often be a missing link which will cause trouble.

Mr. H. R. Bucks called attention to the fact that this committee report represents a large amount of energetic, inventive work on the part of one of our members and a resolution was passed commending both the committee, for its complete report, and Mr. W. J. Bohan, mechanical engineer of the Northern Pac. R. R., in developing this apparatus, which is such a radical departure from all past car lighting practice. Upon motion the meeting adjourned.

Friday P. M. Session

Report of the Committee on Car Wiring.

Before reading the report of this committee, Mr. S. W. Everett (A. T. & S. F. R. R.), chairman, stated that a very serious error had occurred in printing this report, which was by no means intentional on the part of the committee.

Correction of Conduit Specification.

The report as printed specified: "All wiring must be done in approved hot galvanized steel conduit, etc." This should have been, and is so authorized by the committee, as follows: "All wiring must be done in approved *galvanized or sherardized steel conduit,* etc." Mr. Everett stated that he sincerely regretted that this error had occurred and upon motion the secretary was instructed to notify the chairman of the train lighting committee of the M. C. B. Convention and all of the conduit manufacturers regarding this change, and that the RAILWAY ELECTRICAL ENGINEER be requested to publish a full statement regarding same.

The report of the committee, as published in the October number of the RAILWAY ELECTRICAL ENGINEER, was then read by Mr. S. W. Everett with the corrections as above noted. In discussing this report Mr. Cartwright recommended the use of 2½-in. fuses instead of 2⅞-in., as this is a more standard fuse than the 2⅜-in. type. Upon motion this amendment was carried.

Mr. Cartwright also called attention to the fact that the 1/16-in. Cotter key would not prevent a porter from opening the battery switch and causing serious trouble. After some discussion on this point, it was decided to use a removable metal strap instead of a switch and the report of the committee was so amended.

There was much discussion on the subject of generator clearance and it was pointed out that even though a certain minimum clearance be provided when the car is new, this may materially decrease, due to the settling of springs, etc., and when passing over switches, crossings, etc., the bouncing of the car may bring the girder directly in contact with the generator. This fact has undoubtedly been the cause of a few instances of the generator being dropped on the roadbed. Mr. D. B. Pastorius (Pa. R. R.), in discussing the location of train line conduit, stated that probably 90% of the trouble with grounds occur in the train line, conduit junction boxes, etc. He stated that wherever possible the conduit should be run exposed within the car, unless this is objectionable because of symmetry and appearance of the car. Mr. Everett, however, pointed out that it is easy enough to get the car builder to adopt cheaper methods of construction than those specified. The main difficulty in the past has been to get them to properly conceal conduit.

Mr. L. S. Billau (B. & O.) stated that in remodeling a large number of old cars, the B. & O. is concealing all conduit, with the exception of a few cases, in which they are placed on the roof. For all baggage and express cars exposed conduit is located on the ceiling of the car.

Dr. S. Trood, consulting engineer, with the U. S. Sherardizing Co., was then called upon for a few remarks regarding the protection of iron and steel from corrosion. Dr. Trood stated that the subject of sherardizing was so big and so important that it could hardly be covered satisfactorily in a short convention talk and confined himself to some personal reminiscences, which were received with considerable interest by the convention. Upon motion the report of the committee was accepted as amended.

Committee on Outside Construction and Yard Lighting.

The report of this committee, as published in the October number of the Railway Electrical Engineer, was then read by Mr. C. D. Axtell (D. & L. W. R. R.). In discussing this report Mr. J. L. Minick called attention to the greater strength and reliability of the stranded wire over the solid and called attention to the fact that during recent blizzards in the east solid wires were down, whereas stranded wires were able to stand the strain of a 3-in. coating of ice. Mr. Minick also called attention to the fact that where stranded wires of No. 10 size were used failure has frequently occurred, due to the fact that cables are subjected to locomotive smoke which corroded through the wires of small diameter.

After much discussion it was moved that No. 4 B. & S. hard drawn copper be the smallest size wire installed in overhead line construction, and that wherever stranded wires are used strands shall be of a size not smaller than No. 8 B. & S. gauge. Motion was carried.

In discussing the recommendation of the committee that all shop wires be wired underground, Mr. Bucks stated that this should be left optional with each railroad, for unless there is definite assurance that the location is a permanent one, it is not advisable to make an underground installation. He made it clear, however, that wherever the location was assured permanency, his preference was for the underground. Mr. Willard Dowd (consulting engineer, Chicago) pointed out that it is practically impossible to make a definite rule which will fit all cases. While the underground system is doubtless to be preferred as a general proposition, the first cost is usually very high, in some cases prohibitive, and unless there are unlimited funds at your disposal it will require very careful consideration on the part of the engineer as to whether he shall install overhead or underground system. Mr. Minick called attention to the fact that the size of manhole recommended is not by any means offered as a standard. This should be in all cases made to conform to local conditions, depending upon space available, etc. Mr. Axtell (D. L. & W.) cited an instance of where the manholes are but 15 in. wide and in other cases where they are built under the ends of the ties on each side. After some further discussions it was decided to adopt the amendments to the committee report made by Mr. Bucks, as follows: "We believe it desirable to install complete underground conduit system in yards in preference to overhead construction, *with the possible exception of shop grounds,* for the following reasons." Motion was carried.

In further discussing this report Secretary Andreucetti referred to the recommendation for galvanizing pole hardware and moved an amendment as follows: "All of the above hardware is recommended to be of the *hot or cold dip process of galvanizing or sherardizing.*" Motion carried and upon another motion report of the committee was received.

Committee on Illumination.

The report of this committee, as published in the October number of the Railway Electrical Engineer, was then read by Mr. L. S. Billau (B. & O. R. R.), chairman. In discussing this report Mr. Arthur J. Sweet (Vaughan, Meyer & Sweet) referred to an extensive research on street lighting which had been conducted in Milwaukee and stated that much of the information obtained in these tests could be applied to yard lighting. Referring to the matter of glare, he stated that there are two wholly independent considerations involved in what is usually meant by this term, the one meaning the discomfort, due to a bright light or strong contrast, and the other, the blinding effect of lighting conditions decreasing the ability to see. The tests referred to showed that at a mounting height of 15 ft. or less, any unit which gives any candle power above 65 degs. from the nadir, causes blinding effect. Accordingly, either a 65 deg. screen angle or higher mounting is recommended. At 36 ft. height none of the units on the market today cause serious blinding effect. At lower mounting heights they require a higher wattage and more light to see the same thing; for instance, at 12 ft. mounting height an 80 c. p. lamp in a diffusing ball required 75% more illumination in order to see an object clearly visible at normal illumination when a higher mounting is employed. In other words, the mounting height is just as important a factor as the question of lamp efficiency. He also called attention to the fact that the initial high candle power of flaming arc lamps is greatly reduced after a few months' service, due to the gases etching the interior of the opal ball and depositing a black substance which cannot be washed off. Upon motion the report of the committee was received and the meeting adjourned.

Committee on Yard Facilities for Charging Storage Batteries.

The report of this committee, as published in the October number of the Railway Electrical Engineer, was then read by Mr. D. B. Pastorius (Pennsylvania R. R.). In discussing the report of the committee Mr. E. S. McNab (C. P. R.) stated that in Canada the snowfall is usually so heavy that underground outlets for charging lines cannot be satisfactorily operated. A pole line is run between every second row of tracks, and charging leads taken direct from each pole. Mr. Cartwright referred to the fact that there are a number of yards recently installed with overhead construction. Mr. Jansen pointed out, however, that the amount of space available is often the deciding factor, and spoke of the installation in the Illinois Central yards at Chicago, in which one main line distribution is overhead, and from this there are transverse lines underground.

Mr. Billau pointed out that where axle equipments alone are to be taken care of in a yard emergency charging service only is required. He stated that the multiple constant potential system would probably be more expensive than the conditions would warrant, and recommended that the committee investigate this further with a view to a recommendation for yards that handle axle equipment only. Mr. McNab pointed out that even where the charging facilities are for emergency service only this might require the full capacity of the best installation in cases where a severe blizzard delays all trains many hours and all batteries receive severe discharges standing in snowdrifts. Mr. Sloan pointed out that it is entirely impossible to lay down any definite set of rules for designing the yard charging system, as the requirements of each case must be given special consideration. Upon motion the report of the committee was accepted.

Committee on Shop Practice

Friday A. M. Session

This subject is too broad to be treated exhaustively in a report of this nature, so we have considered only the newer and more important developments of recent years.

General.

The adoption of alternating current for power in railroad shops has necessitated the application of a.c. motors to crane and hoist service in many cases, but we find a very strong sentiment in favor of direct current motors and several railway electrical engineers have predicted a general return to d.c. motors for all cranes and hoists eventually. This is due not only to the lower maintenance costs of d.c. motors, but also to the increasing use of dynamic braking and the possibility of using it as a means of returning energy to the line when lowering loads.

The most interesting development in connection with transfers and turntables is the adoption of tractors instead of mounting the motors on the platform direct. Here also alternating current motors are sometimes used, but the greater preference is still for d.c. motors.

In general, we find series wound d.c. motors, or alternating current motors with series characteristics, used for all of these installations, but also find some shops using compound wound d.c. motors.

Cranes.

The general class of apparatus known as "Cranes" is divided into two classes, traveling and stationary, both of which must perform the three operations of raising, moving and lowering loads of various kinds. Since stationary cranes partake so nearly of the qualities of "Hoists," we will limit our report on cranes to the overhead or traveling type.

The best modern practice in crane design and operation dictates the use of three motors, each independent and with separate functions. These are for hoisting the load, propelling the crane bridge along its runway and for moving the trolley or hoisting carriage across the crane body or bridge.

The hoisting motor is the largest on the crane and must be capable of raising or lowering objects of any weight up to the capacity of the crane. It must be able to do this at the highest practical speed, and at speeds which may be varied to suit the load. When two trolleys are mounted on a single bridge, they are each of them usually of about one-half the total capacity of the crane and should be equipped with motors to correspond.

The bridge motor is for moving the crane along its runways or track and must be of sufficient capacity to accelerate both the crane and its load as well as to move them at the desired speed. It need not, therefore, be so large as the hoisting motor.

The trolley motor is merely for moving the hoisting carriage or trolley back and forth across the bridge. It is the smallest of the three motors on the crane, but must be of sufficient capacity to accelerate both the trolley and its load.

In order to insure the highest efficiency, each motor on the crane must be capable of operating at slow positive speeds when the crane is handling heavy loads, and at relatively high speeds when handling smaller loads. The series-wound, direct current motor possesses those inherent characteristics which make it ideal for the requirements of crane service, and we find a tendency to return to d.c. motors in several shops where a.c. motors have been tried for cranes and hoists.

In shops where alternating current only is available wound rotor a.c. motors are used because they possess many of the characteristics of series-wound d.c. motors. This type of motor is built with slip-rings on the armature or rotor so resistance may be inserted in series with the armature or secondary to vary the speed. It can thus be made to handle heavy loads at low speeds with resistance in, or run at practically synchronous speed for handling light loads. Induction motors with squirrel-cage rotors are sometimes used because the torque or pull increases as the speed decreases. They tend to run at constant, synchronous speed on light loads and to slip or slow down under heavy loads, thus being practical for crane service.

The service requirements are such that crane motors must have high starting torque, but also permits the use of motors rated on an intermittent load basis, so it has become customary for most manufacturers to use motors which are really too small for the work. In fact, this condition is becoming so serious that your committee urges that this point be discussed thoroughly at this convention in order that some official action may be taken.

Controllers for crane motors are of two types, drum and disc. The drum type is preferred by most engineers because of its simplicity, ease of repair, interchangeability of parts, magnetic blow-out and being enclosed. It is of the same type as the ones used on street cars, the service is similar and most operators seem to prefer the horizontal rotating motion of the handle. Controllers of the radial arm and face plate or disc type are used on a large number of cranes, however, with entire success.

Since cranes with capacities as great as 120 tons and more have been installed, we find a preference for automatic controllers and self-starters in order to relieve the operator of extreme responsibility by providing against too rapid operation and possible danger to the load and workmen. While it is true that automatic control is most valuable for cranes of the larger sizes, it is also very valuable for smaller ones and could be adopted on all but the very smallest sizes to good advantage.

Another feature of importance for d.c. cranes is the use of controllers arranged to allow dynamic braking for the hoist motors. This facilitates stopping and gives the operator more accurate and positive control over the load handled, and also makes it possible to return some energy to the line because the motor runs as a generator during the braking period. The latter feature is only practicable, however, when the hoisting and lowering are done through considerable distances, so has found very little application in steam railroad shops. The energy generated by dynamic braking is usually dissipated in the form of heat through resistances.

Several railroads have adopted dynamic braking quite generally and they report reduction of not less than 50 per cent in maintenance costs as compared to mechanical brakes. Among the advantages of dynamic breaking are the practical absence of wearing parts, ease of application, accuracy and certainty of control and simplicity. All that is needed is a suitable controller with resistances, and the contacts on the controller are the only parts subject to renewal. The braking effect can be accurately adjusted over a wide range by varying the armature current or field strength by means of suitable resistances.

The current generated tends to heat the motor, of course, so must be considered when selecting motors for this service. Dynamic braking is not used to stop the motors, but merely to slow them down, because the braking action decreases with the speed the same as the output of a generator is reduced with the speed. The final stopping must be done with a mechanical or electrical brake of some kind. Experience also shows that armature troubles are reduced instead of increased by dynamic braking.

When mechanical brakes only are used for lowering loads, the brake is usually controlled by an electromagnet connected in series with the motor. When no current flows the brake is set, but when the motor is working the magnet releases the brake and holds it open until the current falls to a predetermined minimum. Then the brake is allowed to act and help hold the load, its effect being regulated by the starting resistance. The series band brake seems preferable for cranes because repairs are less costly and easier to make than with disc brakes. Extra bands with new liners can be kept on hand and put in place of worn or broken ones quickly.

With disc brakes it is necessary to take the brake apart to renew the plates, and the hubs sometimes become so worn they cause delays for expensive repairs. Another advantage claimed for band brakes is that extra armatures can have a brake wheel attached, where as with disc brakes it is necessary to remove the entire brake in order to change an armature, even though extra hubs may be on hand. Perhaps a coupling between motor and disc brake would simplify this problem and is recommended as worth trying.

The switchboard should be located in the rear side of the operator's cab and be as simple as possible. Good practice indicates a slate panel with fused main switch, two magnetic switches, fuses for each side of each motor circuit and at least two pilot lamps. One of the magnetic switches is placed in the main circuit and the other in the circuit leading to the hoist controllers. The closing coil of the switch in the main circuit should be provided with a plug or other means for opening the switch and locking it open, thus making the crane inoperative and protecting any one working on it. The shunt or closing coil of the switch in the controller circuit should be in series with all limit switches on housing drums. Emergency stops and limit switches are of the utmost importance and should be installed on all cranes and hoists.

Current is supplied to cranes by means of either copper trolley wire or a third rail along the runway, and a trolley wheel or sliding contact shoe mounted on the crane bridge used as a collector. When wires are used it is better to mount them above the runway to keep them away from the hook and cable sheaves, and support them about every fifteen feet with insulators. A heavy strain insulator and turnbuckle should be placed at each end of every wire, and the wires must be far enough away from all steel work to prevent contact when swinging.

When steel third rails are used, as is the tendency for cranes of 30 tons capacity and larger, they should be supported by substantial insulated brackets from the steel framing of the building. Wires running from the trolley wheel or shoe to the main switch in the cab should be well insulated and run through flexible steel conduits with suitable fittings.

Hoists.

The requirements for hoist service are very similar to those for the hoisting motors and controllers on cranes. Series wound d.c. motors or a.c. motors with similar operating characteristics are used, although regenerative control or dynamic braking does not seem to have been used because of the operating conditions.

Hoists are generally used at fixed points and are usually considered as stationary devices, but the use of traveling hoists is increasing so rapidly they must be considered also. This is especially true of monorail hoists or those made to run along on the lower flanges of "I" beams or similar overhead tracks.

There are two types of these used in railroad shops, one consisting of a single car or trolley supporting the motor, hoisting drum, brake and gearing. It is moved along the track by hand, and is also hand operated from the floor by means of cables or small chains, leading up to the controller. This is usually of the disc type and mounted on one side of the hoist body.

The other kind is somewhat larger and more complete, consisting of a moderate sized body containing the hoisting drum, motor and gearing with a cage at one end for the operator and controller. The entire monorail hoist is supported by two trucks or trolleys, each with four wheels, and with a traversing or driving motor on one of the trolleys. These trolleys are swivelled so as to take short radius curves, and the current collector or trolley wheel is generally mounted on one of them by an insulated arm.

The trolley wire or third rail is usually suspended from the "I" beam track, above the trolley, on insulated brackets. They are generally supplied with both mechanical and electric brakes, and the controllers usually allow for a dozen or more speeds. Limit switches are also provided, these being connected in series with the hoist motor and operated by paddle shaped arms extending between the hoisting cables so as to be struck by the sheave block. Stationary electric hoists are similar to the single trolley hoists just described excepting they have a large hook instead of the truck and wheels.

Elevators are also hoists, in the broader sense of the term, but form a distinct group and will not be reported on here more than to say that both a.c. and d.c. motors are now used for that service. Coaling station hoists are also equipped with both a.c. and d.c. motors, many of them having induction motors with squirrel cage armatures and controlled by oil switches and starting compensators. Such coaling stations are usually equipped with continuance gravity bucket type conveyors and do not start up under load.

Another interesting development is the use of remote control for hoist motors in order that the acceleration can be predetermined and taken out of the hands of the operator. This also allows the motors and their controllers to be installed close together and near the machinery, and at the same time be easily operated from distant points. It also reduces the wiring cost and can easily be made to conform to insurance requirements. The Norfolk & Western Railway uses this method of control and has adopted interpole d.c. motors as standard, using push buttons, and finds that the entire cycle of operation has been even more satisfactory than was anticipated.

Transfers and Turntables.

The service requirements of transfer tables and turntables are so similar that we feel it desirable to treat their equipment jointly. In both cases the service is that of accelerating a heavy load and moving it, horizontally, the service is intermittent and it requires a high starting torque.

Where direct current is available, it is considered preferable by a large number of shop men for this service, and series wound, railway type motors are generally used. For transfers, the motors are usually mounted in the motorman's cab or beneath the floor, with the controllers and resistances in the cab. Controllers are sometimes of the disc or face plate type, but drum controllers seem preferable, and, in a few instances, automatic control has been tried with some success. On turntables the motors are mounted either below the floor, as in old installations, or on a tractor in more recent cases, with the controller either in a cab or on one end of the platform.

If alternating current only is available, motors with wound rotors and drum type controllers are generally used; although high torque induction motors have also been tried with some success. For the latter installations, motors giving full load torque at starting when thrown directly across the line, and drawing only 2½ times full load current, have been used. The control of such motors is by means of a double throw switch only, thus eliminating controllers and resistances and giving a very simple type of control. These motors run up to about 25 horsepower in capacity.

The use of tractors for operating turntables is one of the most interesting of recent developments, and these have been applied to old tables as well as new ones. The tractor is a sort of electric truck or self-contained motor car, and carries the motor, controller, resistances and usually a cab for the operator. It is generally hinged to the table and may be equipped with either a.c. or d.c. motor, as required. They may be purchased complete and ready for attaching, and the motors connect with the driving wheels through gears. In case of motor troubles the gears are slipped out of mesh, handles inserted in sockets provided for the purpose and the table operated by hand until the motor has been fixed up.

On account of the rapidly increasing size and weight of cars and locomotives, transfers and turntables are being equipped with automatic starters for the motors, so as to take the acceleration entirely out of the hands of the operator. This is especially important when handling locomotives of the Mallet or Mikado type, because of possible damage to both the mechanical and electrical equipment. This automatic controller consists usually of magnetic switches in the cab, with auxiliary control handle giving three positions: Forward, reverse and off. This is a comparatively recent development, but presents possibilities worth considering.

The feeder wires for transfers are placed along one side of the pit, below the platform level, in some shops, and overhead in others. The preferable method is to have them overhead, either in the center on span wires or at one end on brackets, with a substantial trolley pole and wheel as a collector. Leading in wires to the controller should be carried through flexible steel conduits.

For turntables, the feeders should run underground through heavy conduits and up through iron pipe at least 1½ inches in diameter to the center of the table. Here they fasten to the contractor rings which are stationary and attached directly to the iron pipe in most shops. The brush holders for collector brushes should be substantially attached to the turntable through a swiveling bracket to allow for rocking of the table. The underground wires should be heavily insulated and lead covered, and those from the contactor brushes to the controller should be in iron conduits. On some of the older turntables the feeders run to the center of the table overhead, but this construction is obsolete, and should be changed as rapidly as possible.

Conclusions.

Your committee feels that this subject is of sufficient importance to warrant the appointment of a committee to draw up specifications covering as many points of standard practice as possible, and hereby recommends that this be done.

Respectfully submitted,
Geo. W. Cravens,
Chairman.

Discussion

In discussing the report Mr. Cartwright (L. V. R. R.) gave the results of a series of tests on the D. & L. W., on which a 100-ft. table operated by a 30 h. p. motor required 28 h. p. to start the table loaded, but after getting up speed and turning at one revolution in 55 seconds, it required about 3 h. p. Mr. Pastorius (Pa. R. R.) stated that in considering the horse power required to operate a turntable the type and details of installation of the turntable must be given full consideration. He referred to two turntables identical in design and capacity which have been recently installed, one on solid rock foundation, and the other in a swamp on a foundation of 18 piles. A 15 h. p. motor was installed on each. The table with the rock foundation operated satisfactorily, but that on the pile foundation has given trouble, the motor not being able to start the load. It has always been found, however, upon investigation, that the pile foundation had settled slightly in each case and the table was being carried by the end wheels instead of being balanced on the center. In each case of trouble, after the table had been properly lined up the motor was able to turn the heaviest locomotive on the road. In order to obviate future trouble 25 h. p. motors will be used in future installations. Mr. E. W. Jansen stated that the Ill. C. R. R. has eighteen 85-ft. tables, for the most part equipped with 15 h. p. a. c. motors. He stated that they had a great deal of trouble with the resistance grids breaking and have lately used the carbon pile reversing control with perfect success. This equipment will be installed on future installations.

Mr. Andreucetti stated that they, too, had had a great deal of trouble by resistance grids breaking, due to vibration of the table. Mr. Axtell, however, stated that the D. L. & W. used resistance grids 8 or 9 in. long, and 4 in. wide, and have had no trouble whatever with them breaking. Mr. D. J. Cartwright recommended that the turntables be operated by means of a reversible friction clutch, as this would eliminate the necessity for controlling resistances. Mr. H. C. Meloy suggested that resistance grids be located at the center of the table and, if necessary, placed on spring mountings; the vibration and jar as the engine comes on the table would then be largely eliminated. There was considerable discussion as to the method of collecting current, and it was recommended that a committee be appointed on this subject to consider the methods of installing and operating electric tractors for transfer and turntables. On motion the report of the committee was accepted.

The report of the auditing committee was then received.

Election of Officers.

Officers of the Association for the ensuing year were then elected, and the result of the ballot was as follows:

Mr. H. C. Meloy, President.
E. W. Jansen, First Vice-President.
C. J. Causland, Second Vice-President.
J. A. Andreucetti, Secretary-Treasurer.

Messrs. L. C. Hensel and J. L. Minick were elected members of the executive committee.

At the annual meeting of the Railway Electrical Supply Manufacturers' Association the following officers were elected:

William F. Bauer, Edison Storage Battery Co., President.

T. L. Mount, Consolidated Ry. Elec. Ltg. & Equip. Co., Senior Vice-President.

F. F. Skeel, Crouse Hinds Co., Junior Vice-President.

Edward Wray, Railway Electrical Engineer, Treasurer.

New members Executive Committee:
Wilber E. Fawcett, Main Belting Co.
C. W. Bender, National Lamp Works of the G. E. Co.
A. J. Cole, Westinghouse Lamp Co.

Place of Meeting Next Year

Mr. C. F. Hatfield, Field Secretary of the Panama Pacific Exposition, addressed the meeting, and gave a very interesting and instructive talk on the Panama Exposition. He extended an invitation from the exposition authorities to this Association to hold one of their meetings of 1915 at that place. Secretary Andreucetti pointed out that according to the constitution that the annual meeting must be held in Chicago. After much discussion it was decided to hold the semi-annual convention at the same time and place as that of the Master Mechanics and Master Car Builders' Associations. The desirability of holding some session of the Association in San Francisco was strongly pointed out, and it was shown that according to the constitution it was within the powers of the executive committee to call such a meeting at its discretion. Before adjourning the convention passed a resolution regarding the illness of Mr. A. J. Farrelly, first president of the Association, and instructed the secretary-treasurer to forward Mr. Farrelly a suitable remembrance and expression of sympathy in a bouquet of flowers. A vote of thanks was then extended to the Railway Supply Manufacturers' Association for the exhibition provided in connection with the Seventh Annual Convention of the A. R. E. E. Meeting adjourned.

The Locomotive Headlight

By J. L. Minick

Abstract. A number of states have recently passed laws specifying the light requirements for locomotive headlights, almost all of which virtually exclude all classes of light sources except the electric light. Apparently little thought was given, in the framing of these laws, to the possible dangers accompanying the use of high intensities in the light beam. Tests have been conducted from time to time to determine the dangerous conditions that may arise from the use of various classes of light sources in headlight service. Such data, so far as available, has been collected, compared and analyzed and such points as have been well established are presented in this paper in terms as nearly comparable as possible. Formulas are presented wherever the data available seems to warrant, and conclusions are arrived at by the use of methods differing from those employed in various test reports. The results show that the conclusions and recommendations of the American Railway Master Mechanics' Association are entirely correct if carried out within the limits given in this paper.

The locomotive headlight has been receiving considerable attention for several years past, largely along legislative lines. So far about thirty states have passed laws requiring the use of headlights of comparatively high candle-powers so that, regardless of whether the standards fixed by law are warranted, or whether or not the requirements have been properly stated, it is evident that there is a strong desire for a change from present standards. If this desire could be reduced to concrete facts, it would probably be found that instead of desiring a headlight of higher candle-power, the enginemen actually want one which, when once put in good operating condition, will remain in that condition for some length of time.

It is a very difficult matter to maintain an oil lighted headlight in good working condition constantly. The height of the flame will vary with draught conditions, which in turn are dependent upon the speed of the train, the velocity and direction of wind, temperature, etc. The quality of the oil plays an important part, so also does the trimming of the wick. Excessive heat causes rapid oxidation of the surface of the reflector. This can be removed only by frequent polishing, which in turn scratches, and eventually destroys the reflecting surface.

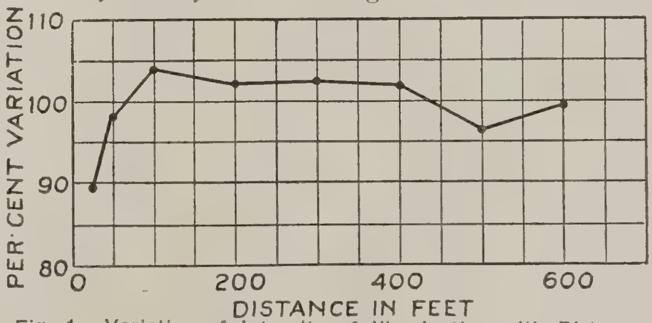


Fig. 1. Variation of Intensity of Illumination with Distance

There are a number of variable factors entering into the make-up of a completed headlight, as, for instance, the diameter, depth and focal length of the reflector, the size, shape and candle-power of the light source, the color value of the light source, the reflecting value of the reflector, the transmission of the glass, etc. It is obvious that reference to only one of these many variable factors does not by any means fix the value of the headlight. Neither does reference to only the distance at which an object can be seen, fix its value.

---

*A paper read at the eighth annual convention of the Illuminating Engineering Society, Cleveland, O., September 21-24, 1914.

It has been suggested that the most satisfactory method of expressing the value of a headlight, is to refer to the candle-power and angular spread of the projected beam. In using this method, however, there are two uncertainties that must not be overlooked. It has not yet been determined definitely that the law of inverse squares holds true for the beam of light (approximately parallel rays) projected by a parabolic reflector or a semaphore lens. Neither has it been determined what distances from the headlight give the most representative readings for calculating the candle-power of the projected beam.

Fig. 1 shows the result of the testing of four 10-inch semaphore type lens headlights (6-inch (15.24 cm.) focal length) equipped with 6-inch (15.24 cm.) prismatic glass reflectors (3-inch (7.62 cm.) focal length) and one 18-inch (45.72 cm.) by 8½-inch (21.6 cm.) parabolic metal reflector headlight (2¾-inch (6.98 cm.) focal length) to determine to what extent the law of inverse squares holds true. These headlights varied in average projected center beam candle-power from 3,442 to 46,000 and in angular spread of beam from about 2° to 7°, the wider angles of spread being for the lower beam candle-powers. The average projected, or apparent beam candle-power as it has been termed, was fixed at 100 per cent for each of the headlights tested. The per cent variation from the average was then determined for each headlight at each reading station. The variations, plus and minus, were then summed up, giving the curve shown. With but one exception the variation for each of the reading stations is well within 5 per cent above and below the average. The one exception is due to one extremely low reading at the 25 foot station. All the other individual readings at this station are very close to 95 per cent, so that if the headlights tested can be taken as being representative of headlights in general, these tests indicate that the law of inverse squares holds within a reasonable degress of accuracy and that readings may be taken at almost any convenient distance, though below 50 feet (15.24 m.) there is probably a greater chance of error than at other points.

About a year ago the American Railway Master Mechanics' Association canvassed the railroads represented by their membership, to ascertain the order of importance of the functions of a locomotive headlight. The replies received represented about 30,000 headlights. A summary of the canvass, both on the basis of headlights represented and number of replies received shows the following order of importance:

1. To warn the public and employes of the approach of a train. (By projecting the beam along the track, thus attracting the attention of persons on the track and warning them of the approach of danger.)
2. To enable the engineman to observe such wayside objects and landmarks as whistle posts, crossings, cattle guards, buildings, etc. (Thus enabling him to gauge the speed of his train and maintain his schedule.)
3. To serve as a marker to designate the head end of a train. (Both ends of a train must be protected at night by distinctive light signals. The size, shape, color, intensity and mounting height of headlight are peculiar to this light only.)
4. To display locomotive or train numbers. (These numbers are necessary for the dispatching of trains. They are usually displayed in the sides of the headlight case and are illuminated at night through slots cut in the reflector.)
5. To enable the engineman to see an object on the track at a sufficient distance ahead of his train to permit stopping in time to avoid an accident.

The functions recited above may be said to be positive in character, *i. e.,* so far as they only are concerned, there need be no maximum limit set for the apparent beam candle-power, except that point beyond which additional light does not assist in the protection of the public, or in the operation of train service. There are, however, several conditions of a negative character that must be seriously considered in selecting a headlight:

1. The intrinsic brilliancy of the beam of projected light must not be high enough to temporarily blind persons and animals on the track, thus causing them to hesitate in moving off the track or to step to another track on which an unnoticed train is approaching.
2. The apparent beam candle-power must not be high enough to blot out colored signals such as classification lights, burning fuses, red lanterns, etc.
3. Apparent beam candle-power must not be high enough or of such color value as to cause a distortion of the color or an apparent shifting of the position of semaphore, switch and other fixed colored signals.

First Function.

In order to warn the public and employes of the approach of a train, the apparent beam candle-power of a headlight must be high enough to be seen at a considerable distance, and yet so low that the intrinsic brilliancy of the beam will not temporarily blind persons and animals on the track.

Range of Projected Beam.—Fig. 2 shows the approximate distance at which a beam of approximately parallel rays of white light may be seen in both rainy and clear weather, by persons in line with the axis of the beam and looking toward the source of light. These curves are plotted from the formulas,

Distance in miles $=1.09\sqrt{\text{Apparent beam candle-power}}$ (for rainy weather),

Distance in miles $=1.53\sqrt{\text{Apparent beam candle-power}}$ (for clear weather),

developed by the German Light House Board at Hamburg. As an example, a beam of 3,000 apparent candle-power can be seen at a distance of approximately 60 miles in rainy weather. Any higher value would be of no value, as the light could serve no useful purpose.

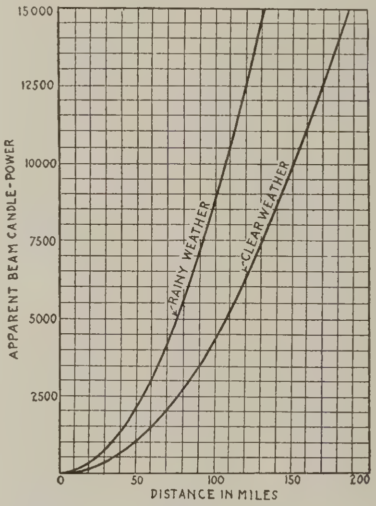


Fig. 2. Approximate Distance Headlights Can Be Seen

The usefulness of the beam of light projected by a headlight is largely dependent upon whether the local contours of the earth's surface are such as to permit the beam being seen at the maximum distance. In the East, where railroads generally follow the course of streams in order to pierce the mountain districts at reasonable grades, the tracks are seldom straight and the beam loses its usefulness. In the West, across the great plains, the track can be laid straight, but the curvature of the surface approaches closely the true curvature of the earth. Fig. 3 shows the distance at which objects of various heights can be seen where the curvature of the surface is true, as at sea, the observer's eye being tangent with the surface. As an example, the average height of the headlight above the rail is about 10 feet (3.05 m.). If the observer's eye be placed at the focal center of the headlight, the horizon will be at a distance of 4.18 miles (6.73 km.). The height of the eye above the rail, of the average man standing on the ties, is approximately 5 feet, and the horizon to him will be at a distance of 2.95 miles 4.74 km.). The sum of these two distance, 7.13 miles (11.47 km.), is the distance at which the beam from a headlight 10 feet above the rail can be seen by the average man, where the surface has a spherical shape.

The earth's surface does not always follow this true curvature, so that it is quite possible, where it is flat or where dips in the track exist, to see for distances of 20 or 30 miles (32.18 or 48.28 km.). The minimum limit of the apparent beam candle-power should be fixed at a value which would permit seeing the headlight at this distance. Fig. 2 shows that a beam of 500 apparent candle-power can be seen at a distance of about 25 miles (40.23 km.) in rainy weather and at about 35 miles (56.32 km.) in clear weather. As express trains seldom exceed a speed of 60 miles (96.56 km.) per hour, or a mile (1.60 km.) per minute, the time allowance of 20 minutes or more, between the first warning and the arrival of the train, should be ample for the protection of both the public and employes.

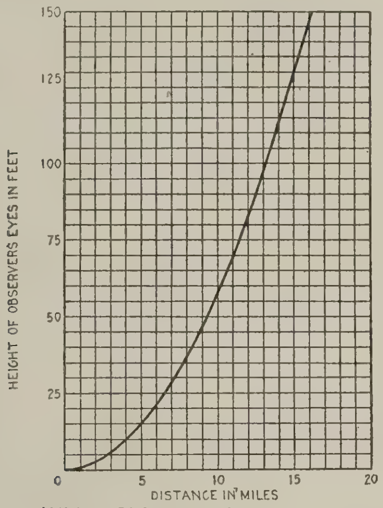


Fig. 3. Distance Which Objects of Various Heights Can Be Seen at Sea

Intrinsic Brilliancy of Projected Beam.—It has been stated that the intrinsic brilliancy of sources of light exposed to view, should not greatly exceed 0.10 to 0.20 candle-power per square inch (6.45 sq. cm.). This value is fixed, however, from the standpoint of safety and good practice in the design of the usual classes of interior lighting. A review of the technical data available does not fix any values for the maximum to which the eye can be subjected momentarily without producing a state of temporary blindness. Personal observation fixes this value at about 30 or 40 candle-power per square inch for locomotive headlights. To be on the safe side this value should undoubtedly be decreased by at least 50 per cent. Fig. 4 shows the intrinsic brilliancy for beams of various apparent candle-powers from reflectors of the diameters in common use today. It will be noted that a 16-inch reflector, giving a beam of 3,000 apparent candle-power, has a value of about 15 candle-power per square inch 6.45 sq. cm.) of projected area, a value well within the limits of safety.

Second Function.

The engineman maintains his schedule by gauging the speed of his train largely with the vibration of the parts of his locomotive, but it is very desirable that he recognize while passing, such wayside objects and land marks as whistle posts, buildings, grade crossings, bridges, etc. It is only necessary for him to see these objects as he passes them, or at a range of 50 or 60 feet (15.24 or 18.29 m.) ahead of the locomotive. Such objects are seldom farther than 20 feet (6.09 m.) from the center of the track. A line drawn through the focal center of the headlight and passing through the point 50 feet (15.24 m.) ahead of the locomotive, 20 feet from the center of the track and 3 feet (0.91 m.) above the rail, makes an angle of approximately 22½° with the axis of the beam. By referring to Fig. 5, showing the maximum and minimum values of apparent beam candle-power recommended by the Master Mechanics' Headlight Committee, it will be noted that the minimum value for an angle of 22½° is 30. Reducing to foot-candles, this value becomes approximately 0.10 foot-candle or about 7 times the intensity of moonlight, which should be sufficient to enable the engineman to perform this duty.

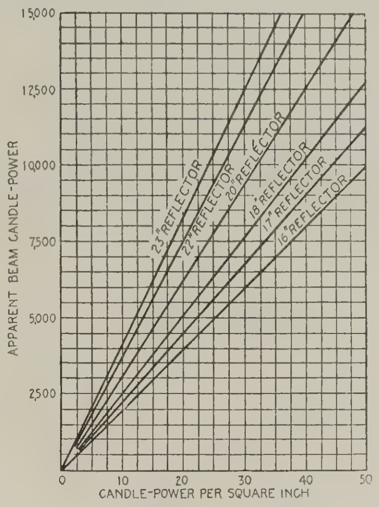


Fig. 4. Relation of Size of Reflector to Intrinsic Brillancy of Beam

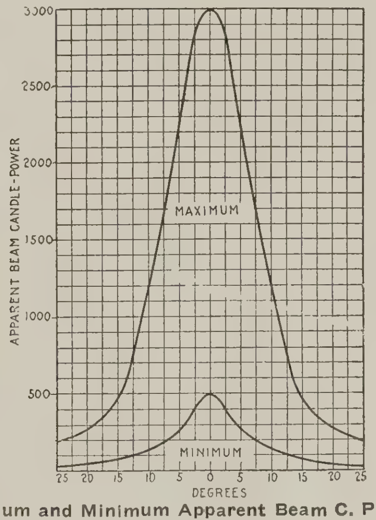


Fig. 5. Maximum and Minimum Apparent Beam C. P. Recommended by the Master Mechanics' Headlight Committee

Third Function.

The rules for the operation of train service require that both the front and rear ends of a train shall be protected and identified by light signals at night, some of which may be colored either red, green, or white. Depending upon the direction of movement, class of train, etc., there may be as many as 5 lights on the front end of a locomotive, one of which is invariably the headlight. The headlight is used only on the front ends of trains in main line service. The diameter of the reflector, intensity of beam and mounting height above the rail, are all characteristic of the headlight and are not duplicated in any other light used in the operation of train service.

Fourth Function.

In the operation of train service, the number of the locomotive is used by the train dispatcher and tower men to identify the train. The numbers, therefore, must be illuminated at night. The headlight has long served as this source of light, the numbers, ordinarily set in the sides of the headlight casing being illuminated through slots cut in the reflector.

Fifth Function.

Much has been said in an effort to make this fifth function, that of enabling the engineman to see an object in time to stop his train and avoid an accident, appear to be the only important function of the headlight. A brief study of the practical conditions of train operation will show this statement to be both untrue and opposed to the safe operation of trains.

The average man dresses in what may be termed dark clothes. The Columbus tests show conclusively that there is no headlight offered for sale today as a commercial product, that will enable the engineman to see a man in dark clothes at a safe stopping distance. These tests also show that even moderately high apparent beam candlepowers will blot out colored signals entirely, or will so distort their color as to give a false indication, both of which conditions are extremely dangerous to the safe operation of train.

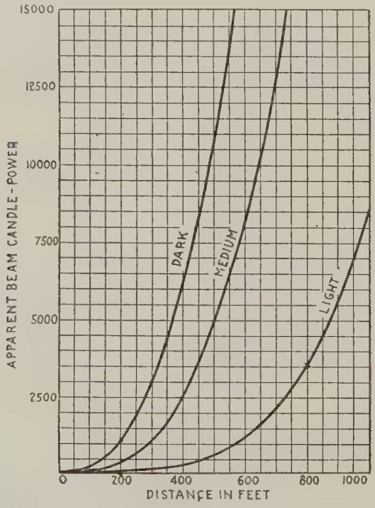


Fig. 6. Distance Which Various Colored Dummies Can Be Seen With Gas and Oil Headlights.

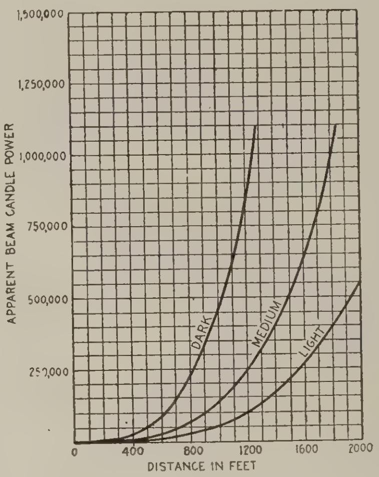


Fig. 7. Distance Which Various Colored Dummies Can Be Seen. With Arc Headlight.

Range of Visibility of Objects on the Track.—In the Columbus tests an effort was made to determine the distances at which objects on the track could be seen by the use of headlights of various apparent beam candle-powers. Where comparisons can be made, the Columbus tests in this as well as in other respects are confirmed by the tests at Avon, Ind., at Madison, Wis., and at Tinley Park, Ill., and by individual tests by the following railroads: N. Y. C. & H. R. R., C. G. W. R. R., M. C. R. R., C. & N. W. Ry., and B. & O. R. R. Fig. 6 shows the results of the tests with incandescent lamp, gas and oil-lighted headlights. The objects used were dummies, slightly larger than the average man in size and shape, dressed in overalls; the "light," in the white ordinarily worn by butchers, bakers, etc., the "dark" in the blue worn by trainmen, shop hands, etc., and the "medium" in an alternate blue and white ¼ in. wide, vertical shape. The curves shown in Fig. 6 have been plotted from the three following formulas developed from the data collected in the tests:

$$\text{Apparent beam c. p.} = \frac{1.061}{10^3}\,\overline{(\text{distance in feet})}^{2.60}$$

(for dark dummy).

$$\text{Apparent beam c. p.} = \frac{3.81}{10^5}\,\overline{(\text{distance in feet})}^{3.0}$$

(for medium dummy).

$$\text{Apparent beam c. p.} = \frac{8.54}{10^9}\,\overline{(\text{distance in feet})}^{4.0}$$

(for light dummy).

These curves differ slightly from those published in the Master Mechanics' report, as the formulas had not been developed at the time the report was written.

The results obtained by the use of arc-lighted headlights differed radically from those obtained by the use of other types of light sources, in that the distances at which the dummies could be seen were much shorter. It was not possible, on account of lack of time, to investigate the reasons for this difference. It is probably safe to assume, however, that it was due largely to the color value of the light source, all of the arc lamps being rich in the shorter wave length. Fig. 7 shows curves for the arc headlights plotted from the formulas:

$$\text{Apparent beam c. p.} = \frac{2.25}{10^5}\,\overline{(\text{distance in feet})}^{3.44}$$

(for dark dummy).

$$\text{Apparent beam c. p.} = \frac{5.79}{10^6}\,\overline{(\text{distance in feet})}^{3.43}$$

(for medium dummy).

$$\text{Apparent beam c. p.} = \frac{6.04}{10^6}\,\overline{(\text{distance in feet})}^{3.32}$$

(for light dummy).

These arc light curves are presented only as an indication of what may reasonably be expected. The arc lamps used in the tests, presumably of the best construction obtainable, were very erratic in regulation, even when operated from storage batteries of 300 ampere-hour capacity. The apparent beam candle-power varied as much as 30 to 50 per cent above and below the average selected as the rating of the lamp, whereas the variation with all the other sources of light did not exceed 6 or 8 per cent above and below.

Safe Stopping Distance.—Fig. 8 shows two typical deceleration curves for emergency stops from a speed of approximately 60 miles (96.56 km.) per hour for a train of 12 standard class P-70 all-steel passenger coaches and a class K-2-sa locomotive. This is the equivalent of the present day through express or limited train. Curve No. 1 is for the most modern type of single shoe air brake rigging and equipment at present in regular service, while curve No. 2 is for a 2 shoe electro-pneumatic system now in process of development. It is expected that this latter system will be in rather general use within the course of the next few years. It will be noted that the present day emergency stopping distance is approximately 1,660 feet after the application of the brake, while that of the near future is about 1,235 feet (376.42 m.).

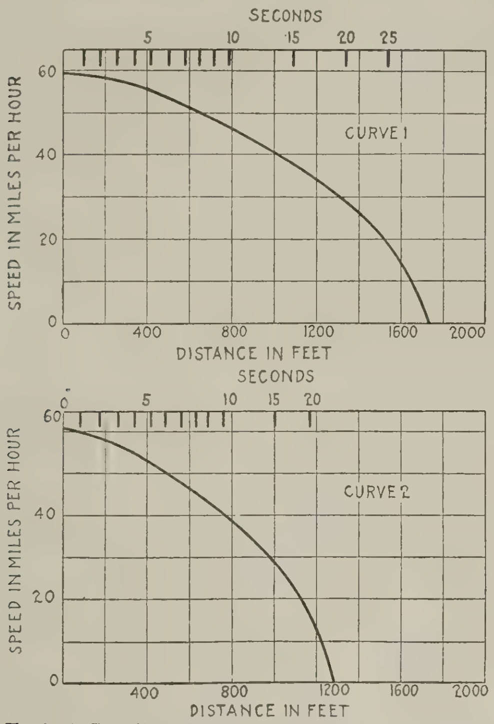


Fig. 8. Typical Decelleration Curves for Emergency Stops With Twelve Car Passenger Train, Speed 60 M. P. H.

In the Columbus tests it was found that the dark dummy could be seen at a distance of about 500 feet (152.4 m.) with an apparent beam candle-power of approximately 10,000 for an incandescent lamp headlight, while it required about 60,000 from an arc headlight. This distance was increased to 1,237 feet for an arc light of 1,000,000 apparent beam candle-power. Incidentally this is the extreme distance at which there is a contrast between the object and the background, and is not the distance at which the object assumes shape and form. It is, therefore, evident, that none of the headlights tested at Columbus (the variety covered all commercial sizes and types, over 200) had sufficient apparent beam candle-power to enable the engineman to see an average man on the track in time to stop his train and avoid an accident, and that it is doubtful whether the engineman could see him at even the prospective future emergency stopping distance.

It must not be forgotten that the engineman does not apply his emergency at the exact instant he thinks he sees an object on the track. He first waits until the object begins to assume form and shape, after which he endeavors to attract attention by blowing his whistle. This all requires time, probably 50 to 75 per cent of the time required for making an emergency stop, so that the locomotive has passed the safe stopping distance for the average man by several hundred feet, at the instant the emergency is applied.

Classification Signals.—It is necessary in the operation of train service, that the engine and tower men shall be able to identify all trains passing them. A means of identification has been provided in the form of classification lamps. At the head end of the train, these are placed one on each side of the front end of the locomotive, at about the height of the horizontal axis of the smoke box. Under certain conditions additional lights are sometimes placed on the ends of the pilot beam. These lights are usually white or green, while red and combinations of one green and one red are used at the rear end of the train.

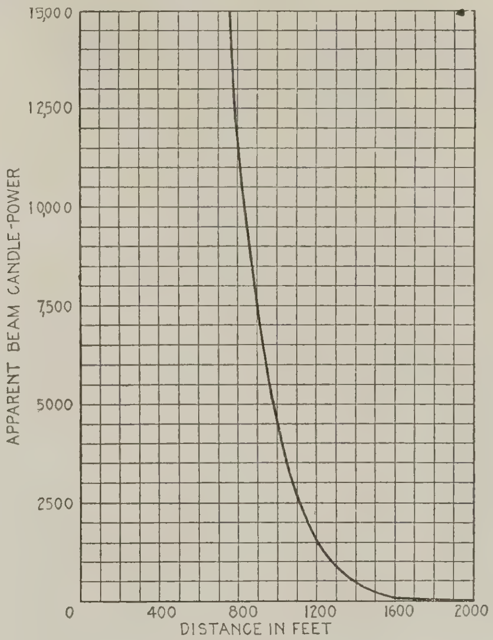


Fig. 9. Distances at Which Classification Signals Can Be Read Correctly With Opposing Headlights of Equal Apparent Beam

The most difficult condition under which it is necessary for the engineman to read these signals, is that of 2 trains approaching each other, head on, on adjacent tracks. Under this condition the opposing headlight tends to interfere with the proper reading of the signals. Fig. No. 9 shows the distances at which classification signals can be read correctly with opposing headlights of equal apparent beam candle-powers. This curve has been plotted from the formula:

$$\text{Apparent beam candle-power} = \frac{4.65}{10^{12}} \overline{(2,000 - \text{distance in ft.}}^{5}$$

developed from data secured in the Columbus tests. This curve also differs slightly from that shown in the Master Mechanics' report.

When the two locomotives approach each other on adjacent tracks, the classification lamps on one locomotive are obscured to the engineman on the other, by the front end of his locomotive when the two locomotives are about 600 feet (182.88 m.) apart. With opposing headlights of 2,500 apparent beam candle-power these lights can be correctly identified at about 1,100 feet (335.28 m.). Subtracting the 600 feet above referred to gives 500 feet (152.4 m.) for the movement of the train before the signals disappear. For express trains running at 60 miles per hour, this distance, 500 feet, is equivalent to slightly less than 3 seconds, during which time the signal must be read.

Semaphore and Switch Signals.—The Columbus test shows some very peculiar, as well as interesting conditions in connection with the operation of colored light signals, when headlights of comparatively high apparent beam candle-powers are used. Light falling upon a rounded or signal lens will be reflected in some degree. Depending upon the position of the roundel or lens, the intensity of the headlight beam, etc., the light may be reflected back to the engineman, or it may be refracted, under which condition the signal will assume an entirely different color. In a number of instances green or white indications were secured from red roundels, a condition that is extremely dangerous, since white means safety to the engineman, while red means danger or stop. This condition is very pronounced when the lamp in the signal lantern is not lighted, although when the lantern is lighted, it is sufficiently pronounced to be dangerous, especially with the higher apparent beam candle-powers.

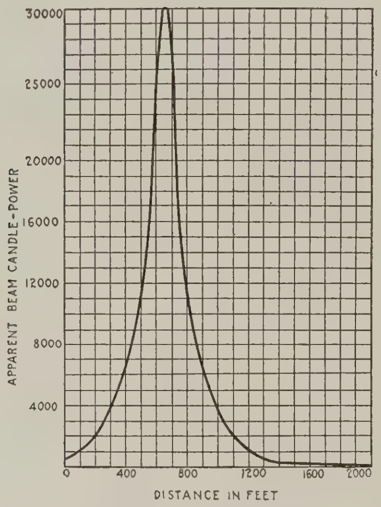


Fig. 10. Region in Which False Indication of Signals Are Usually Apparent

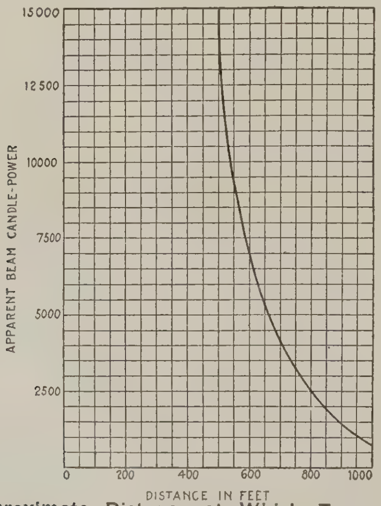


Fig. 11. Approximate Distance at Which Fuses, Red Lantern, Flags, Etc., Give Correct Indications

Under certain conditions the signal indication may disappear entirely, and this applies to hand signals as well, or it may have the appearance of having been shifted from its former position. Dwarf switch signals are very liable to these troubles.

There also appears to be a fairly well defined region in which fixed signals of this character can be read correctly, while outside of this region it is almost certain that there will be false indications. It has not been possible so far to so analyze the test data available as to plot curves for each kind and color of signals. All of this data has been lumped together, however, giving the curve shown on Fig. 10. A formula has not been developed for this curve because the test data is somewhat incomplete at certain distances, and also because the incorrect observations must be discounted to some extent to cover possible errors in noting the observations, tabulating, etc.

Colored Hand Signals.—Fig. 11 shows the approximate distances at which fuses, red lantern flags and other hand signals may reasonably be expected to give correct indications. The data for all of the hand signals used has been lumped together and a formula for the curve has not been developed, for the reasons above given.

Comments and Conclusions.

The first or most important function of a headlight fixes the value of the apparent beam candle-power from the standpoint of its being a sign of warning of the approach of danger. The data given in the first paper shows that the maximum and minimum values of apparent beam candle-power (3,000 and 500, respectively) recommended by the Headlight Committee of the Master Mechanics' Association are well founded.

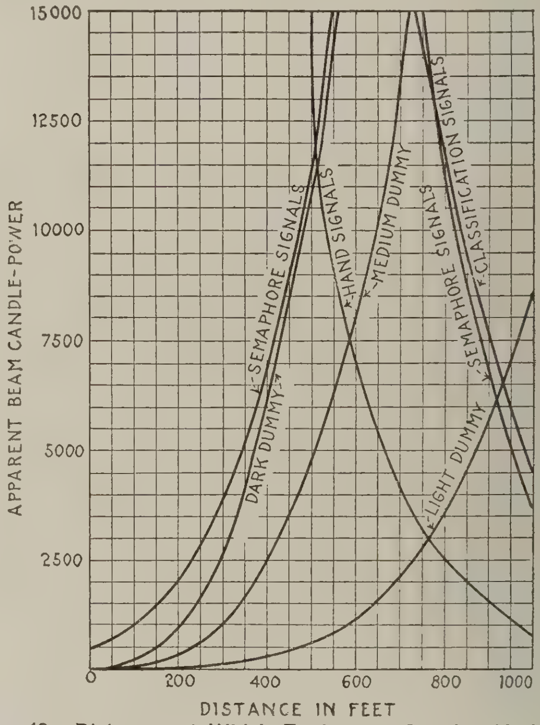


Fig. 12. Distances at Which Engineman Can See Various Signals

The fifth, or least important function, fixes the value from the standpoint of enabling the engineman to see objects on the track without there being any interference with the reading of colored signals. The maximum and minimum values may be readily determined by plotting all of the visibility curves on one sheet and noting the points at which the various curves intersect each other. Such a plot is shown on Fig. 12, and this also confirms the Master Mechanics' recommendations. It will be noted that there will be difficulty, at distances less than the maximum at which the light dummy can be seen, in correctly identifying classification lamps with more than 6,500 apparent beam candle-power; semaphore signals with over 6,000 and hand signals with 3,000.

All of the headlight tests conducted to date have developed very interesting and very valuable data. In the reports of tests, however, the data has not always been presented in such shape that it can be compared with that of other tests. The effort has been made in this paper to present such data as is available, in terms that may be conveniently measured and compared. Some of the data herewith is not complete nor definitely established, and it is to be hoped that others will endeavor, as tests are conducted in the future, to prove or disprove the correctness of the curves and formulas given, and in addition, to develop such new formulæ as the results of the tests may seem to warrant.

The practice of referring to the wattage of the lamp, the diameter of the reflector, the candle-power of the lamp, the distance at which an object can be seen, etc., in attempting to establish the value of a headlight, should be discouraged as much as possible, as its value cannot be fixed in this manner. Reference to the apparent candle-power and angular spread of the projected beam should be used instead.

Future investigations should include: The establishment of an accepted method of photometering, an analysis of the color values of the several light sources, the determination of the effect of variations in the color value of the projected beam upon the visibility of objects and signals, and the fixing of standards for the size, shape, etc., of light sources.

Manufacturers' Exhibits

At A. R. E. E. Convention

The Adams and Westlake Company had a very interesting exhibit consisting of a panel arranged in the shape of the side and ceiling of a car. The fixtures and lamps were placed in their relative positions. Both direct and indirect fixtures were on exhibit. Several styles of "Unity" fixtures for mail and baggage cars were shown, as well as direct and indirect units for day coaches, diners, parlor, and sleeping cars. Various types of half deck lamps, recessed vestibule reflectors and conduit fixtures and also several varieties of berth lamps and a round house lamp were shown on the side wall.

Exhibit of A. & J. M. Anderson Mfg. Co.

The representatives of the company were: Messrs. G. L. Walters, C. B. Carson, A. S. Anderson, W. J. Pierson, J. F. Stender, A. L. Galt, and W. S. Hamm.

The American Pulley Co. showed both flanged and flangless axle pulleys for car lighting, and pressed steel bushings for either the M. C. B. or Pullman standard axles. Their pressed car wheels for hand cars were also shown. Mr. J. J. Forest and Mr. C. P. Englehart represented the company at the convention.

The A. & J. M. Anderson Mfg. Co. had a very comprehensive exhibit of their appliances of interest to railway electrical engineers. On one panel were shown various types of plugs and receptacles for battery charging on automobiles and in shops, universal plugs and receptacles for use where stationary receptables would likely be injured. A second panel showed plugs and receptacles suitable for railroad yard charging. Plugs were on exhibit fitted with three different kinds of handles, composition, aluminum and malleable iron. One 220 volt 200-300 amp. plug was shown for use with electric welding outfits. The improved type C plug was fitted with an extended ring support which prevents chafing of the cable and danger from short circuit.

Two time switches fitted with eight-day clocks were shown, one being provided with a heater coil for outdoor use in cold weather. A 600 amp. knife switch was shown. Two panels were used to exhibit line materials, insulated turnbuckles, strain insulators, insulated bushings, split spool insulators, trolley ears, connector hangers, circuit-breakers, etc. Messrs. W. W. Hincher and G. D. Durham were the company representatives.

Appleton Electric Company exhibited their approved line of stamped steel "Unilets" and conduit fittings. Many new fittings have been added to this line, such as vaporproof unilets for use in railroad yards, etc.; also pull boxes, cutout unilets, service entrance unilets, the latter being shown in a 5-in. size.

One of the noticeable features was the large 4-in. rectangular unilet, which is drawn from steel, as are the pull boxes. The pull boxes are made for 1-in. to 4-in. conduit inclusive and in several different lengths, making them very handy for use around buildings where a great many wires must be drawn through. A very complete line of Outlet Boxes and Extensions were also shown. The company was represented by Messrs. R. P. Tillotson and D. G. Welling.

Appleton Electric Co.'s Booth

The Benjamin Electric Mfg. Co.'s Exhibit was a radical departure from former years, their booth being fitted up as a luxurious reception room. Instead of showing a complete line, they only had samples of the newer devices of particular interest to railway electricians.

Among these were cast iron top single units for heavy duty in round houses, yards, etc., where gases will tend to corrode the metal parts; a complete line of reflector sockets, angle reflectors and fixtures for type "C" gas filled lamps; also, lamp grip receptacles for use where vibration is excessive, and which would tend to allow lamps to loosen from sockets; weather proof Benco sockets, mogul sockets, and signal receptacles, together with fiber shock proof hand portables.

The company representatives were Messrs. H. E. Watson, A. E. Lubeck, R. C. Mons, and G. B. Weber.

The Central Electric Company kept "open house" at their familiar location in the northeast corner of the Exhibit Hall. Materials featured were Okonite wires and cables, among which several new departures were noted, particularly steel braided cables for various purposes where unusual physical protection is required; also Okonite with fireproof outer braid, especially desirable for locomotive wiring; D. & W. high tension oil break current, service boxes, fuses, and Deltabeston wire. The utility of the latter was strikingly demonstrated by a headlight armature wound with flat Deltabeston after the manner described in the September issue of the RAILWAY ELECTRICAL ENGINEER.

The new Maxolites equipped with Central Electric Type R fittings, especially the sizes indicated for Type "C" lamps were shown for the first time. Other lines given special attention were the railway coach lighting fixtures (semi-indirect types) Alberyl glassware, Ralco receptacles and plugs, and the LCT locomotive junction boxes. Diehl railway type fans, including the exhaust fans and sirocco blowers were exhibited in operation, and attracted a great deal of attention.

Messrs. Lorenz, Woodhead and Baker were in attendance, assisted by Messrs. Martin, Candee and Kyle of the Okonite Company and Mr. Marvin of the Diehl Mfg. Company.

Exhibit of Benjamin Elec. Mfg. Co.

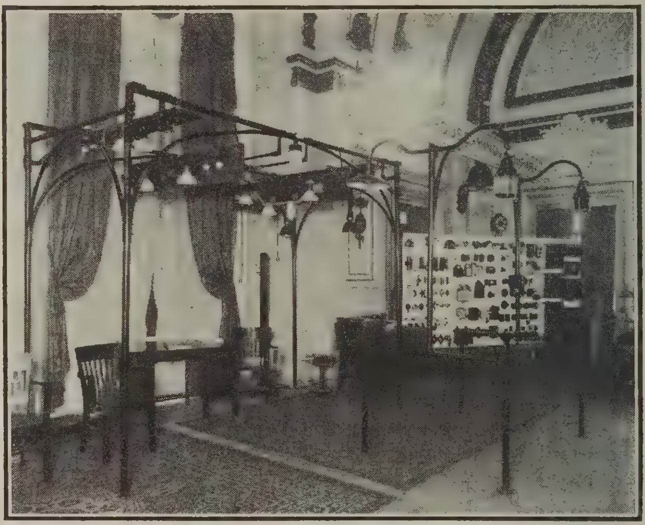
CHICAGO FUSE & MFG. CO. exhibited a very complete assortment of fuses and fuse accessories. All the samples were placed on a single sample board, of novel design, each half of which revolved about its own center. On one panel were shown enclosed fuses, fuse blocks, and conduit outlet boxes and switch boxes. Fuses—enclosed and link—both ferrule and knife blade types were shown. The sizes varied from 3 to 1,000 amps. and from 6 to 600 volts. A combination switch and cutout and a metal fuse box for ferrule type enclosed fuses were also shown, the latter being one of their most recent developments. The company's representatives were: Messrs. A. S. Merril and H. P. Collins.

Chicago Fuse Mfg. Co.'s Exhibit

The CONSOLIDATED RAILWAY LIGHTING & EQUIPMENT Co. had an operating exhibit of their axle generator lighting outfit. Generators, types D-4 and D-5 were shown, D-4 being equipped with Timkin bearings, and D-5 with No. 412 ball bearings. The apparatus was adjusted to operate at all speeds up to 90 m.p.h. By merely throwing a switch it could be operated on either a battery of Edison or lead cells. The construction of their metallic resistance units was very well shown by the display of spare parts.

Corner Occupied by Central Electric

An interesting departure from their usual construction of the interpole was shown, these being wound with flat ribbon wire insulated with mica. A type A armature with a removable shaft was shown, as well as spare parts, showing the method of winding. All the generators were fitted with the improved type pole changer which could be seen in operation on the operating generator. Messrs. D. N. Balderston, W. R. Hungerford, and T. L. Mount represented the company at the convention.



Commodious Quarters of Crouse-Hinds

CROUSE-HINDS Co. exhibited a most complete line of condulets, charging plugs, receptacles and other railway specialties. Several other articles of interest consisted of yard charging equipment for underground conduit mountings, a double receptacle housing, a surface conduit mounting and an improved type of M.C.B. receptacle with self-aligning contacts. A complete line of plugs for shop use and for charging were shown in sizes for 30 to 200 amperes. There was also shown a yard charging condulet with a single receptacle designed for mounting on posts or side walls. Another interesting development was a yard charging condulet with two charging receptacles and a 10 ampere receptacle for a vacuum cleaning attachment, another was arranged with a special base plate for mounting over hollow piers. Several round house reflectors were shown for illuminating the repair pits, one was made to conform to the safety first movement, being fitted with a red glass with the words "Safety First" left in white. A new vestibule light was shown—by loosening just a few screws the receptacle was made immediately accessible. Several types of mail car fixtures were also on exhibit.

Their new bulletin No. 1000 was given to all those interested, as well as supplements 1000a and 1000b. Water tight service boxes, built to marine specifications, were also on exhibit. Of the other kinds of condulets on exhibit were those designed for use with heating units, vapor proof condulets and a full line of condulets for side rail and center deck lighting. Many of the new condulets were fitted with a flange for a support. A complete line of composition covers is furnished for use in all installations where the regulation porcelain cover does not meet with the requirements. The company's representatives were: Messrs. W. M. Fagan, F. F. Skeel, A. F. Hills, C. H. Bissel, E. G. Smith, T. C. Fleischer, C. M. Crowfoot, J. A. Amos, E. C. Otto, and Chas. Dubsky.

The Geo. Cutter Company, in their interesting exhibit, showed several new fixtures for high efficiency Mazdas, known under the trade name of "Mazdaarcs." The automatic series cutout created considerable comment, for by this means a series arc lamp can be lowered and cut out of the circuit without interrupting the service of the other lamps. Various other types with reflectors and diffusing bowls were on exhibit. At the entrance to the booth were placed two park view lamp posts. The McWilliams metering panel board models showed how meter circuits in tall buildings can be changed from the switch board without changing the wiring. The McWilliams Panel board with the bus-bars arranged above each other showed how by its economy of space it was adapted to be used in car lighting work.

Exhibit of Consolidated R. L. & E. Co.

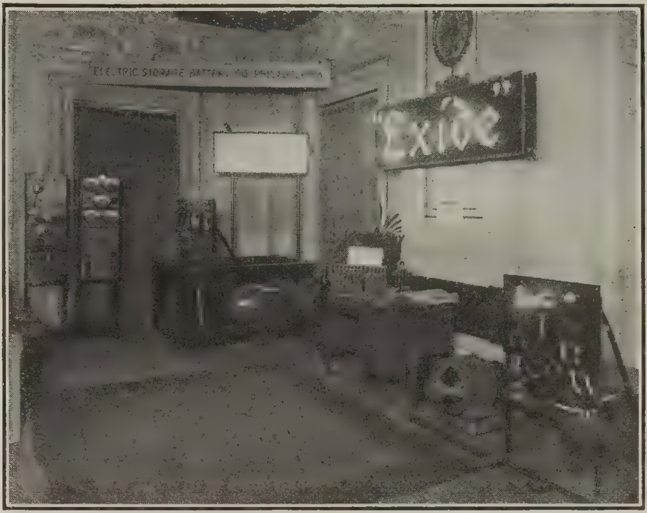
Several types of plugs and receptacles for two and three phase portable motors were shown. The company's representatives were: C. A. Howe, Mr. Otis Duncan, and Mr. Fred Duncan.

Among the many interesting features of the Delta-Star Electric Co's. exhibit was a working model of one of their high tension outdoor sub-stations. This was fitted complete with air break switches and lightning arresters. A large number of photographs showed actual installations of these outdoor stations.

Automatic and non-automatic train connectors, axle generator connectors, signal and charging plugs and receptacles, welding plugs and receptacles were on exhibit. A high voltage testing set was shown capable of being shorted across a 60,000 volt line. Other interesting exhibits were cable fault finders, high tension bus-bar supporters, choke coils, and carbon-tetra chloride fuses for use on high tension lines. Messrs. H. W. Young and A. S. Pearl represented the company.

The Economy Fuse Co. had a very attractive exhibit. On a large panel board fuses, both ferrule and knife switch types, ranging in size from 3 amperes, 250 volts to 600 amperes, 600 volts, were effectively arranged. A 400 amp., 600 volt fuse was shown in section, giving a very clear idea of how the fuse is inserted and the method of construction. Messrs. A. L. Eustice, A. E. Tregenza, W. J. Guntz, and J. B. Griffith were the company's representatives at the convention.

The exhibit of the National Metal Molding Co. showed very effectively how their product could be used in conjunction with other kinds of molding by means of various kinds of connectors. A small model installation showed with what ease the molding could be used in turning corners and running over projections from the wall. Tools for shearing and punching the molding were on exhibit. A various assortment of samples of their flexible conduit, armored cable and sherarduct were shown. In a glass covered case was shown samples of sherarduct in different stages of manufacture. The factory representatives were: Messrs. I. A. Bennett, H. C. Moran and Dr. E. H. Trood.



Booth of E. S. B. Co.

Edison Storage Battery Co. had a very attractive booth, for besides the usual decorations four canaries added their songs to the attractiveness of the booth. Their exhibit showed the construction and assembly of the new Edison Nickel-iron cell. The company's representatives at the convention were: Messrs. H. G. Thompson, W. F. Bauer, F. V. McGinness and C. A. Luckey.

Edison Storage Battery Co. "At Home"

The Electric Storage Battery Co. exhibited their car lighting outfit to good advantage. Their new E.S.B. axle-generator was shown mounted on a dummy truck with the E.S.B. suspension and driven by a motor at variable speed. The generator was connected to a standard E.S.B. lighting panel mounted with a test panel to show its operation. One peculiar characteristic of this equipment was its ability to develop the right polarity even with reversed fields. The voltage would build up in the wrong direction, the automatic switch would open for an instant and the pole changer would operate to correct the polarity. This change occurred so quickly that the lamps only winked slightly. Sixteen cells of carlighting batteries were used, type E.C.S., 17 Manchester Box. A Hyray house lighting outfit was also shown. It operated at 32 volts and was equipped with a Sangamo meter to show the condition of the charge. In practical operation the outfit is run with a gas engine and uses Exide batteries. The representatives of the company were: Messrs. J. L. Woodbridge, F. G. Beetam, O. R.

Shortall, H. M. Beck, G. H. Atkins, T. Milton, and J. L. MacBurney.

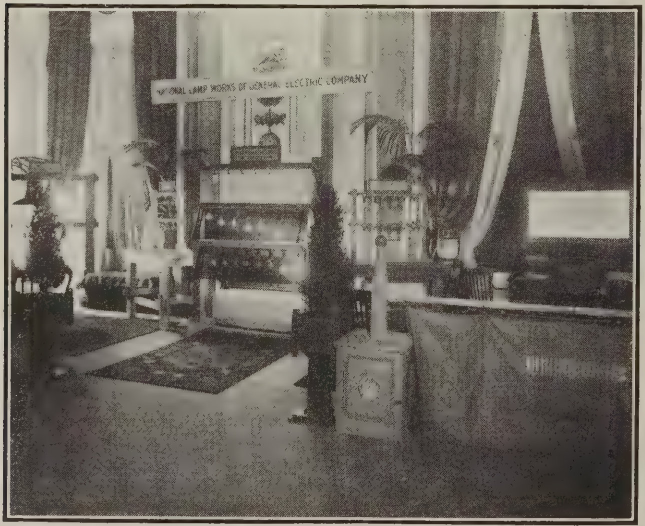
The Electrical Testing Laboratories had a reception booth with free telephone and easy chairs and literature explaining the nature of the work done by the company. Mr. N. D. McDonald was the company representative at the convention.

The Federal Sign System had on exhibit their new electric lantern for trainmen, which throws no bottom shadow. The battery used has a capacity of 50 hours. A flasher lamp, using a number 6 dry cell, for use in car repairing and engine oiling was of interest. Federal clamp sockets and porcelain bushings and fixtures for outside and indoor installation for use with high efficiency mazdas were shown. The company's representatives at the convention were Mr. L. Shepard and Mr. F. T. Baird.

The Flexible Steel Lacing Co. had on exhibit an abundant assortment of belt fasteners ranging in size from tape fasteners to steel lacing for belts 6 feet wide. A handy tool for making joints on carlighting belts was shown. The belt is clamped on either side of the joint and when the ends are pulled together by means of a rack and pawl arrangement, the pin is inserted. Mr. G. E. Purple represented the company at the convention.

Exhibit of Holophane Works

General Electric Co's. booth was arranged very effectively. A locomotive headlight equipment was set up complete with generator headlight and conduit system. All the lamps and the conduits were placed in the same relative position as they are on the locomotive. The headlight was equipped with a 165 c.p., 6-volt, 108-watt nitrogen filled lamp. The steam gage and water glass lamps were connected by armored cable and the engineer's lamp, the firema's deck lamp and the classification lamps were connected to condulets.



Double Booth of National Lamp Works

The turbine and generator were partially dissembled to show the ease with which the armature could be removed and to show the voltage regulating device, as well as their mechanical construction. The company was represented by B. F. Bilsland, S. W. McCune, R. H. Parker, C. Jones, C. C. Baiiey, J. A. Wetherbie, and J. Scribner.

The Gould Coupler Co. had a very interesting exhibit, showing their types G and C axle generators, connected up as a motor generator set to a standard Gould Simplex lamp and machine regulator. The lamp bank was mounted on a separate panel. A model pole changer was mounted so as to be turned with a crank to show how it operated. An armature shaft assembled complete with ball bearings attracted attention. Special tools for applying and removing these bearings was shown.

Booth of Peerless V Belt Co.

One of the new Gould Vitrified Clay battery boxes proved to be of interest to the spectators. The company was represented by Messrs. G. G. Milne, W. F. Bouche, I. M. Noble, G. R. Berger, M. R. Shedd.

The Harter Manufacturing Co. featured their new cast-iron fixture known under the trade name of "Nitrolite" for use with the new mazdas. A special cast-iron unit was used to demonstrate the ease with which this unit could be wired and assembled. Other standard fixtures made by the company were also on exhibit. The company's representatives were: Messrs. W. M. Soffe, G. A. Harter and C. G. Fries.

Safety Car H. & L. Co.'s Exhibit.

The Holophane Works of the General Electric Co. had a very complete line of shades, diffusing bowls and reflectors on display. For the multiple type C mazdas several "Realite" units were shown; opal enclosing units, a unit with a deep bowl and shallow dome, prismatic reflectors, and enameled reflectors for outdoor and indoor use. The result of some of the recent development in opal ball units, called "Truetint," were also to be seen. These units are made to produce certain color values and are of especial service in accurate color matching. Prismatic glass reflectors, in heavy, medium, and light weights, steel reflectors both blown and pressed, and a complete line of glass and metal reflectors for car lighting and decoration were also on exhibit. The new prismatic units are very useful in controlling and directing the light effectively in illuminating large areas, such as yards, etc. Mr. L. C. Doane represented the company at the Convention.

Exhibit of U. S. L. & H. Co.

The Kerite Insulated Wire & Cable Co. exhibited numerous samples of their insulated wires and cables. The company's representatives were: B. L. Winchell, Maj. Azel Ames, J. W. Young, P. W. Miller, and G. A. Graber.

The Main Belting Co. had a spacious and well decorated reception booth. They showed samples of their Leviathan car lighting belt. Messrs. W. E. Fawcett and F. A. Zundars were the company's representatives at the convention.

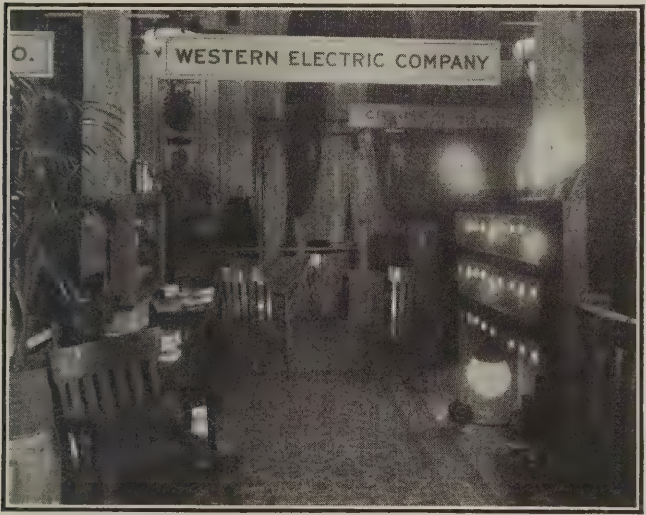


Exhibit of Western Electric Co.

National Lamp Works of G. E. Co. occupied a double booth on the south side of the exhibit hall. A complete assortment of nitrogen filled and mazda lamps of interest to the convention was shown on four racks. In the center and under smoked glass the series and multiple nitrogen filled lamps were placed. The series lamps ranged in sizes from 600 c.p. down, and the multiple lamps varied from 200 to 1,000 watts. A large enclosing bowl fixture for use with the nitrogen lamp, and known under the name of "Frontlite," for use in front of moving picture treaters and other public places, was shown. On a third rack locomotive headlight lamps, also of the nitrogen filled type, were shown in a variety of sizes for both 6 and 30 volts, another rack was devoted to train lighting lamps for use in 32 volt circuits. These lamps were shown with both round and straight sided bulbs. Aside from several 110 volt mazdas the entire exhibit represented the progress of the past year. The representatives of the company at the convention were Messrs. C. W. Bender and L. C. Kent.

Williard Storage Battery Co.'s Reception Booth

The Oneida Steel Pulley Co. exhibited their new Keystone axle pulley, which has a rim nearly twice as thick as is usual in this type of pulley, it being made of $\frac{3}{16}$-in. stock. Bevel flanges 2½ in. high are provided. The arms support the rim at the joint. Their standard corrugated bushing for use with axle pulleys was also on exhibit. The company's representative at the convention was Mr. N. D. Stark.

The instructive exhibit of the Peerless V-Belt Co. consisted of belt links and spare parts showing the construction and method of applying the belt. A variable speed motor connected to a prony brake by means of a V-belt was used to demonstrate its great driving power even with no initial tension. Pulleys for generators and axles for use with this belt were shown. Messrs. J. E. Cagney and J. R. Sharp represented the company.

The Pyle National Headlight Company exhibited their type E turbo-generator and arc light equipment. The headlight shown was fitted with one of their new copper ventilated electrodes and holders. An adjustable support for incandescent tungsten lamps was shown. The incandescent headlights were for 30-32 volt service. The turbine and the turbo-generator was partly dissembled and the rotor removed to show the construction. The turbine was fitted with the new improved balanced governor valve.

The company was represented by Messrs. J. W. Johnson, J. E. Kilker, Chas Dake, and Wm. Miller.

The booth of the Railway Electrical Engineer was located at Convention Headquarters, and Messrs. C. D. Sperry and Edward Wray and Miss Estelle Pearce represented the company at the convention.

Safety Car Heating & Lighting Co. exhibited a complete line of equipment of interest to railroad men. The model of a car truck, with a belted generator attached, showed the mounting and method of suspension for Safety generator. A standard "Safety" panel and metering board, connected to Williard "Nowash" batteries, were shown. A 3 k.w. axle generator was run with a motor at variable speed. A direct connected magneto recorded the m.p.h. The metering board showed voltage, amperes, miles per hour, and the output in watts. A standard 4 k.w. generator was on exhibit. A model mounting of the brushes showed the operation of the pole-changer.

On the arch in front of the booth several types of their new car lighting fixtures were shown. Of especial interest was the new combination unit combining a fan with the lighting fixture. This was described in the August issue of the Railway Electrical Engineer.

The representatives of the company were: Messrs. A. C.

Moore, G. E. Hulse, J. Rogers, C. A. Pinyard, and W. H. Reader.

Sangamo Electric Co. showed different types and constructional features of their ampere-hour meters. On one panel they exhibited an ampere-hour meter of 500 ampere-hours' capacity. On a second panel was shown the Pennsylvania type ampere-hour meter, mounted on a slate base with a double pole circuit-breaker, which both prevents overcharging and restores normal operation of the equipment. A third panel supported a new type D5 switchboard watt-hour meter. An unassembled meter showed the construction features. The different dial faces used by the company on their various ampere-hour meters were also on exhibit. The company's representatives were: Messrs. R. C. Lanphier, M. B. Southwick and J. T. Hartley.

R. Thomas & Sons Insulator Co. occupied part of Western Electric's booth. They exhibited one of their crossing protectors. These insulators are used on crossings or in other places where the wire is apt to be damaged or the insulator broken. Besides the regular petticoat insulator, the wire is protected from arcs by two iron arms over which the wire passes. Messrs. H. R. Holmes and R. W. Harmes represented the company.

The U. S. Light & Heating Co. had several things of especial interest in their exhibit. One of these was a shaft adapter by means of which a plain oiled bearing can be adapted for use with ball bearings. The flexible polechanger leads were insulated with glass beads so as to allow of the greatest flexibility with no danger of cracked insulation.

A regular U.S.L. regulator and type B-4 generator were on exhibit, and a type C 100 amp. machine. The generator regulator and battery current regulator were mounted for inspection. An outfit with a 1 k.w. generator and small capacity batteries was shown for use in baggage or mail cars where the batteries are to be set on the floor of the car. A commutator insulated with Bakelite proved of unusual interest. The commutator was sawed so as to show the method of anchoring the segments. the company's representatives at the convention were: Messrs. C. C. Bradford, W. L. Bliss, L. R. Pomeroy, R. C. Haley, C. A. Schaffer, G. Dunnop, H. A. Matthews, R. E. Stuntz, W. J. Stuntz, W. J. Pennington, and G. Hentges.

Western Electric Co. mounted their lamps on a large rack alternating the new type C mazda lamps with the regular tungstens. The relative brilliancy of the filaments in the two lamps was very noticeable as is shown in the photograph of the booth, the brilliancy of the type "C" filament having caused a reversal of the image, making it appear black. The other exhibits consisted of flash lights, lanterns, and interphones. A case showing a Sunbeam lamp in various stages of construction was of interest. The new lamps on exhibit were the Vacuum type B and type C. The company's representatives were: Messrs. G. H. Porter, G. F. Kelly, and P. W. Greene.

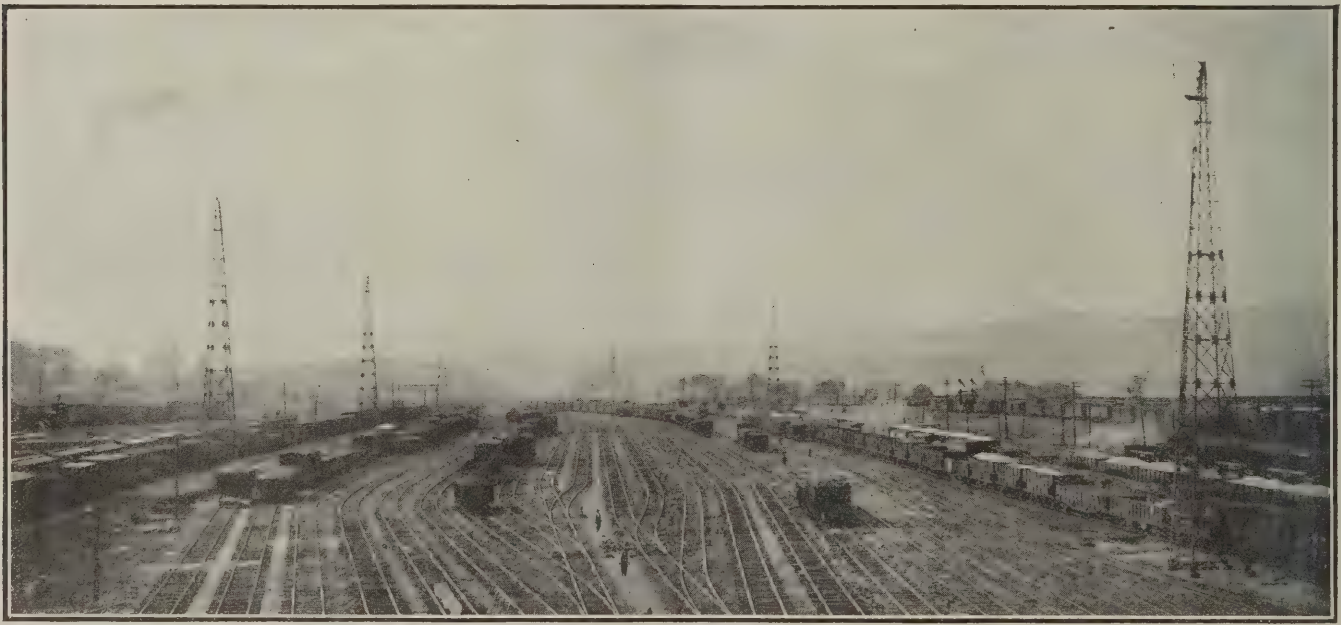
In the booth of the Westinghouse Lamp Co. were on exhibit several pendant lamps which swung so that at the end of each stroke the lamp struck a rubber button. This demonstrated that the modern mazda is not frail, but is rugged and durable. Several large fixtures for new nitrogen filled lamps were on exhibit. Units for both indoor and yard lighting were shown. On one rack lamps for locomotive headlights and train lighting were arranged. The company was represented by Messrs. A. J. Cole, W. H. Rolinson, A. N. Brown, and J. G. Harvey.

The booth of the Willard Storage Battery Co. was most attractively and beautifully decorated. In the center of the booth and against the back wall was placed a sunburst of the Willard "Nowash" battery. Multicolored autumn leaves and flowers gave the booth a very striking appearance. An uncovered battery showed the construction and the arrangement of plates in the new "Nowash" battery. The company was represented by W. D. Ballantine, H. S. Gardner and T. D. Smith.

Classification Yard Lighting

Of the P. & L. E. R. R. at Pittsburg

It is a very generally known fact that the average railroad derives its revenue principally from freight traffic, often carrying passengers at a loss. Therefore, anything that tends to facilitate the movement of cars or handling of freight is looked on with favor by the railroads.



Classification Yard of the P. & L. E. R. R. Showing the Arrangement of the Steel Towers Which Support the Lighting Units.

Of the very greatest importance in freight handling but little known to the general public because of its infrequent contact therewith, is the classification yard. The function of this yard is the collection of freight cars into trains for specific destinations or routes. After the train has been made up with its proper quota of cars, it proceeds to the receiving yard where it waits until opportunity is afforded for it to pass out over the scales and be weighed, and proceed thence on its route.

The car or group of cars entering the yards travels by gravity under the care of a rider who directs it to its proper place in the yard and from whence he returns afoot to the head of the yard where additional cars are obtained and distributed.

As these yards are in operation 24 hours a day, it may easily be realized how important it is to have them properly lighted.

An interesting discussion of the lighting of railroad yards is given in a paper recently presented by Messrs. H. Kirschberg and A. C. Cotton on "Railroad Illuminating Engineering Track, Scale and Yard Lighting," before the Pittsburgh section of the Illuminating Engineering Society.

The authors state that the freight haulage capacity of a road is as dependent on the scale and yard capacity as it is on motive power equipment, and that a congestion in the yards will reduce the earning power just as effectively as the disablement of a locomotive or other rolling stock.

The lighting of an area such as is presented by this class of yard affords some unique problems, the successful solution of which greatly facilitates the movement of freight traffic. The yard is not to be considered as an open area, but, in reality, as a series of streets three or four feet wide, with buildings (freight cars) about fourteen ft high, on both sides.

One of the most effective installations of lighting in a classification yard recently made is that of the Pittsburgh and Lake Erie Railroad at McKees Rocks, just outside the city limits of Pittsburgh, Pa. This yard contains about twenty tracks extending for approximately one-half mile.

The source of light is the Cooper Hewitt quartz lamp, mounted on steel towers, as shown in the accompanying illustrations. The installation consists of eight units, the lamp being rated at 2,400 candle power, with an energy consumption of 726 watts, resulting in an efficiency of .3 watts per candle. Direct current at 220 volts is supplied to the lamps from the power plant of the company located nearby.

The towers, which are twelve feet square at the base, are 100 feet high and are spaced about 400 feet, in two rows one on each side of the yard, or approximately 225 feet across. The lamp is suspended from a short mast arm which extends out over a platform for the attendant, access to which is had by means of a ladder mounted on the side of the tower.

A chain and a cut-out, however, permit the lamp to be lowered from the ground, thus obviating the necessity of the lamp attendant climbing the tower.

As the quartz burners have a life of several thousand hours, and the globes are at such a height as to be out of the smoke zone, almost no cleaning or other attention is required.

The ideal condition of illumination of the yard, is of course, to make it as light by night as by day, so that the riders, when directing the cars to their proper spaces in the yard, may be able to see clearly the location of other cars and thus prevent them from excessive "bumping."

The illumination of the McKees Rocks yards, which has been installed under the direction of Mr. D. P. Morrison, electrical engineer of the Pittsburgh and Lake Erie, very nearly approaches this ideal condition.

The light given by the lamps spaced as they are, completely floods the yards, enabling the men to see with proper clearness, not only every track and car but also the switches at the head of the yard. The illumination is such that one may readily read a newspaper at night. The absence of shadows and glare greatly facilitates the movement of the cars throughout the yard, by permitting the exact location of each to be easily determined, and also greatly adds to the safety of the men and tends to prevent accidents.

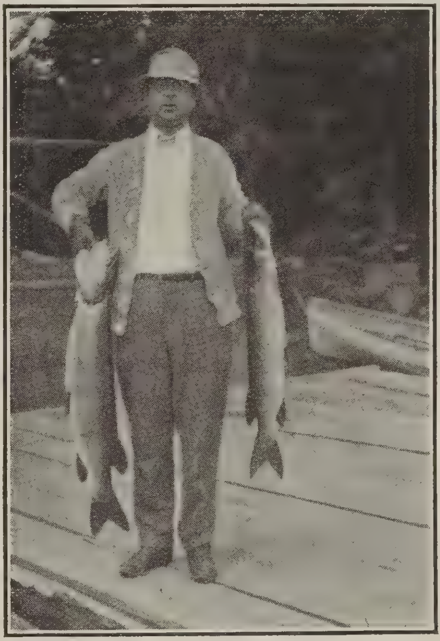
Possibly the best commendation given the efficiency of the installation is the statement made by one of the railroad officials that "the yard men never lose any chance to praise it." Considering the well known reluctance of the average individual to praise his working conditions, this statement is peculiarly significant.

In addition to the increased speed in handling cars gained through the better lighting, conditions are made much easier for the men returning afoot to the head of the yard, as when the yard is poorly lighted, it is difficult for them to avoid incoming cars, switches, posts and other obstacles, and the Pittsburgh and Lake Erie employees are particularly pleased with this feature. The fact that the lamps are mounted at such a height permits an excellent distribution of the light.

The installation has not been in service long enough for any operating data to be secured, but in view of the high efficiency of the quartz lamp and the minimum attendance required, it is confidently expected that the costs of operation will be equally as satisfactory as the other features of the installation.

Another Fish Story.

Remember that big 40-lb. "Musky" that Secretary Andreucetti *said* he caught last year?—Well, just to show you that he can "come back" he went up there again this year with Claude Bender. Joe caught the big one, a 15-lb. "Musky," and Claude, the other, an 8-lb. one.



Joe in the Wilds of Northern Wisconsin

Intra-Mural Railway at Panama Exposition.

To eliminate the bugaboo of leg-weariness at the Panama Exposition the intra-mural steam railway, with its five miles of steel track is being constructed. Eight modern Pacific type locomotives each weighing 12 tons, equipped with air brakes, standard automatic couplers, electric headlight and six drive wheels will be used. Each little giant will have 10 miniature passenger coaches and run on a regular schedule on its double track.

A. B. C. Car Lighting Course

Edited by Edward Wray

Lesson No. 34

Pintsch-Grob (German) System

We believe that much can be learned from a study of some of the axle car lighting equipments in use in foreign countries and a thorough knowledge of foreign equipments may lead to some suggestions for improving certain features of American equipment. Accordingly, this lesson will be devoted to a study of another foreign system, the Pintsch-Grob system, an axle lighting system which is extensively used on the trains of the Swiss Railways, the Prussian and Saxony State Railroads, Austrian, Danish and Russian Railroads.

This system is radically different from any other system previously described. It operates on substantially a constant potential principle of regulation. The diagram, Fig. 177, illustrates this principle fairly well, although this is only a partial diagram to illustrate the principle of regulation.

The Regulator.

It will be noted that the exciting current is furnished by the battery Z and, since the battery positive terminal connects through the winding E to the generator positive terminal B, the amount of current flowing through this winding E will depend upon the difference between the generator voltage across BA and the battery voltage. Assuming for the moment that the battery voltage is 32 volts and the generator is also 32 volts, there would then be no current whatever flowing through the field coils E and the generator voltage would immediatly drop. As soon as it falls even a fraction of a volt, however, this allows current to flow from the battery through the field coils E and tends to hold up the generator voltage. The voltage of the generator, however, can never quite equal that of the battery. As the train speed increases the generator voltage would tend to rise, but this would simply reduce the exciting current and the generator voltage will automatically be maintained practically constant.

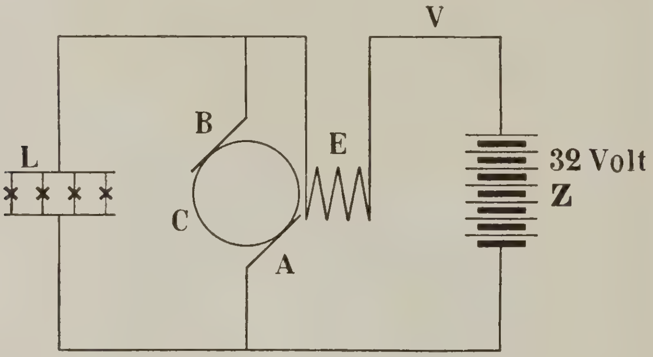


Fig. 177. Diagram Showing Principle of Regulation

The field coils E are wound with heavy wire of low resistance so that a difference in potential between battery and generator of one volt will be sufficient to cause full exciting current to flow through the field coils. Even when the generator speed is at the minimum cutting in speed (600 R. P. M.) the manufacturers state that the field consumes but 5 watts. At higher speeds the exciting current gradually decreases, as less excitation is required to generate 32 volts. The generator voltage across BA is then maintained constant at a fraction of a volt less than the voltage of the regulating battery Z. When a heavy lamp load is turned on, which would ordinarily cause a reduction in generator voltage, the exciting current through E automatically increases slightly so as to keep the generator voltage at approximately constant value.

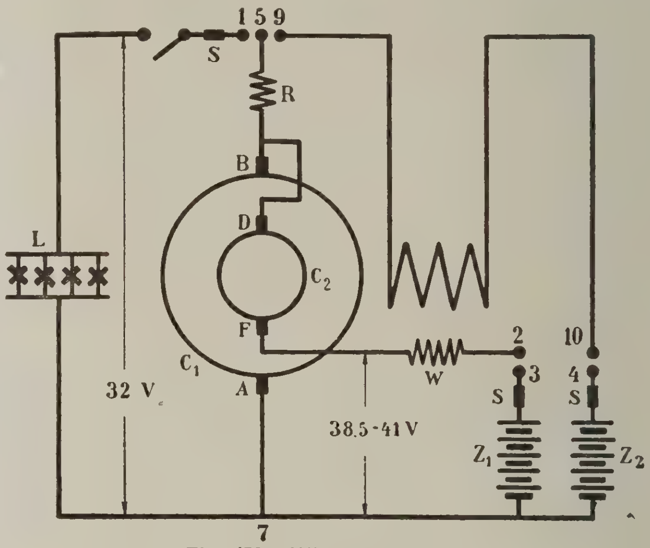


Fig. 178. Wiring Diagram

Battery Charging.

The question immediately comes to mind, "If the generator voltage can never be quite equal to that of the storage battery, how can it charge the battery?" It will be noted upon referring to diagram Fig. 178, that two batteries are employed. On discharge both of these batteries are connected in parallel across the lamps, the point 1 being automatically connected to points 3 and 4 by the centrifugal automatic switch being open. When operating on the road, however, one of these batteries is being charged, while the other one is employed for controlling voltage, as explained above. In order to bring the generator voltage above that of the battery so that it can force charging current into the battery, a second winding is placed on the armature and this has a separate commutator C-2, with brushes DF. This winding revolves in the same magnetic field that the main armature winding does, so practically constant voltage will be generated in this auxiliary winding as well as in the main winding.

These windings are connected in series so that with about 6½ volts generated across the brushes DF, and 32 volts across the brushes AB, will normally deliver a total charging voltage of 38½ volts. This voltage will be maintained constant irrespective of train speed, lamp load, etc. This is assuming the open circuit voltage of the battery being used for regulation to be constant at 32 volts. Accordingly the battery will be charged on a constant potential basis, the charging current being fairly high at the start and tapering off to a lower value at the end of charge. The resistance W is added in the battery charging circuit so as to prevent excessive flow of charging current into a low battery at the beginning of charge.

The battery charging current then flows through the following circuit: B-D-F-W-S-Z-7-A.

It should be noted that the voltage of the generator in both the main and secondary armature windings will vary with the open circuit voltage of the battery which is being used for regulation since the current through the field windings E will automatically adjust itself so as to keep the generator voltage AB about 1 volt below that of the battery being used for regulation. Since both batteries are connected in parallel at every stop and also the connections 3 and 4 are automatically reversed at every stop, as explained later, both batteries are kept in approximately the same state of charge. When both batteries are nearly charged then, the open circuit voltage of the regulating battery will probably be 34 volts. This will cause 34 volts to be generated in the main armature winding and about 7 volts in the auxiliary armature winding, making a total of approximately 41 volts. Furthermore, with both batteries in a very low state of charge the open circuit voltage of the regulating battery might be as low as 30 volts; this would generate 30 volts in the main winding and approximately 6 volts in the auxiliary armature winding, giving a total generator charging voltage of 36 volts. In this manner excessively high currents at the beginning of charge are prevented and current at the end of charge is automatically boosted slightly so that it does not come to as low a taper at the end of charge as it would on a strictly constant potential basis.

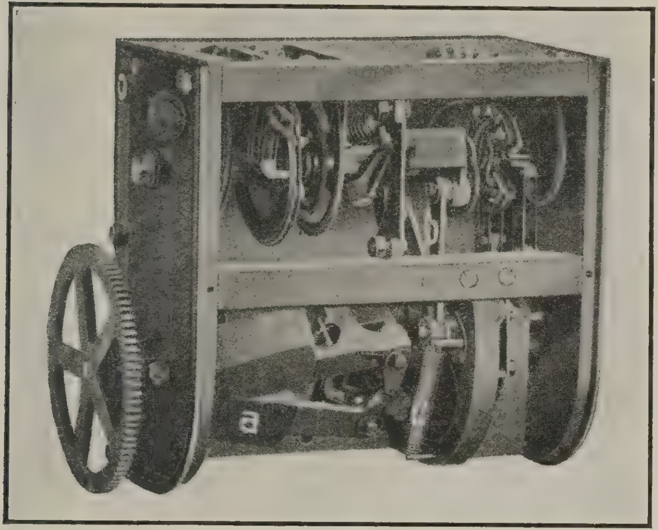


Fig. 179. Mechanically Operated Pole Changer and Automatic Switch

Automatic Switch.

This switch is of the ordinary fly ball governor type, and when the generator speed gets up to 600 r. p. m. the weights A are thrown outward sufficiently to raise the lever B, opening the connection 1-3-4 and closing 1-5-9, 2-3 and 10-4. Another feature of the switch is that at each stop it automatically reverses the connections 3 and 4 so that each battery after one stop is used for regulating generator voltage, and after the next stop is given a charge, the other battery then being used for regulation. The pole changer is also included in this automatic switch and this operates to reverse the direction of current through the field winding when the direction of car motion is reversed. This double reversal then, always maintains the same polarity of generator voltage.

Lamp Voltage Regulation.

As explained above, the voltage of the main armature winding of the generator is maintained practically constant at slightly less than the open circuit voltage of the regulating battery. Accordingly, no other lamp regulation is provided. It is well known, however, that the open circuit voltage of a battery is by no means constant, but varies considerably, depending upon the state of battery charge. Accordingly, a corresponding variation in the operating generator voltage might be expected.

In order to provide a more rapid charge of the battery at night when frequent discharge at stops may seriously deplete the battery, the resistance R is manually switched into the lamp circuit. This will automatically increase the voltage across AB and DF, for it will be noted that the generator field current automatically adjusts itself so as to produce a voltage across 5-7 practically equal to that of the regulating battery. In other words, the voltage across AB will be higher than that of the regulating battery or that across 5-7, by an amount equal to the voltage drop in the lamp resistance R. It should be pointed out, however, that this does not affect the voltage delivered to the lamps since the voltage across 5-7 is maintained constant at about equal to that of the regulating battery. The lamp current flows through the following circuit: B-R-5-1-S-L-7-A. Interpoles are provided on the generator for neutralizing armature reactions and preventing excessive sparking on heavy load.

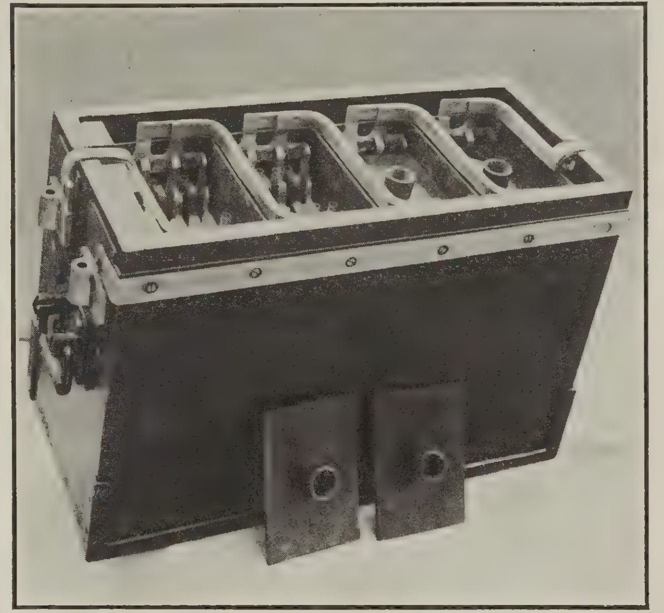


Fig. 180. Showing Novel Construction of One Type of German Battery. Each Tray Contains Four Cells Connected Permanently in Series by Straps as Shown

---

Pennsylvania "School of Electricity."

The publication of the lessons prepared by the Penn. R. R. "School of Electricity" has been temporarily held up on account of retrenchment in all departments, so these lessons will be omitted for a few numbers. The schedule of the remaining lessons includes some highly interesting and instructive matter, pertaining to the operation and design of electrical equipment for electric traction, motors, generators, etc.

The Railroad Electricians' Club

Meetings the 3rd Monday of Every Month, 8 P. M.—18th Floor Transportation Bldg., Harrison and Dearborn Sts., Chicago—Everybody Welcome—No Dues

Lead Storage Battery Questions

Prob. 41. What are the advantages and disadvantages of a constant potential yard charging system?

Ans. 41. For most railroad coach yards, the constant potential system of charging will probably give more satisfactory service than any other system. Its first cost will be considerably cheaper than individual circuit control system, although it will be more expensive than the series yard charging system. Another advantage is that it is much simpler to take care of than the individual circuit control, since with a proper installation of ampere hour meter control the equipment may be made to operate automatically so as to cut off at the proper time. Another advantage of the constant potential system is that the charging rate at the beginning is usually two or three times normal rate. This makes it possible to give the battery a good charge in a short time without injury. On the other hand, the charging current tapers to low value at the end of charge, and injurious gassing at the finish is eliminated. Another advantage of the constant potential system is that the switchboard and generating station are extremely simple and there is practically no switchboard-attention required.

A disadvantage of the constant potential system is that at each charging plug a resistance of one value must be inserted for the lead battery and a resistance of another value for the Edison battery. Another disadvantage is that unless the ampere hour meter operates properly, or if a car without an ampere hour meter is charged on this system, it may be seriously overcharged because of the fact that the charging rate even at the end of charge is usually almost normal rate, and the attendant may be relying on the car taking care of itself.

Prob. 42. What are the advantages and disadvantages of a series yard charging system?

Ans. 42. The series yard charging system is the cheapest of any to install. Since the potential drop in the charging line is of no importance and since several batteries are charged in series, the current for all being the same as that required for one with any other system, a small size wire can be used in making connections to charging receptacles in the yard.

A serious disadvantage of the series system is that no two batteries will be received in the same condition of discharge. In other words, if three batteries are connected in series and all fully charged, two of these batteries will undoubtedly be overcharged to a greater or less extent. In trains lighted on the straight storage system, where all batteries receive approximately the same amount of discharge, the series system may be very satisfactorily employed, but such cases are rare. In many cases where the series yard charging system has been installed car lighting men have been forced to put first cost ahead of operating results and maintenance cost.

Prob. 43. What are the advantages and disadvantages of an individual circuit control yard charging system?

Ans. 43. The main advantage of the individual circuit control yard charging system is that it is possible to give each battery individual treatment. Its disadvantages are that it requires an excessively large switchboard and the cost of installation, as well as its operating cost, is rather high.

Prob. 44. What causes a battery to warm up when it is either charged or discharged?

Ans. 44. When an electric current passes through a storage battery either on charge or discharge the ohmic resistance of the battery opposes the flow of current and heat is generated. The heat generated by electric current flowing through a resistance may be compared to the heat generated by friction. It is simply energy, electrical in one case, and mechanical in the other, changed into the form of heat.

Prob. 45. What is the highest temperature a battery should be operated at? What will happen if the temperature goes above that value?

Ans. 45. It is impossible to give any definite temperature above which a battery will be injured, and below which it will not be injured. All high temperatures tend to increase the sulphation of the plates. The higher the temperature the greater will be the tendency to sulphate.

The length of time at which a battery operates at the high temperature is also an important factor. For instance, a battery operated continually at 85 or 90 deg. will not retain its capacity as well as one that is operated at a lower temperature, or as well as one that may be only occasionally operated at a temperature even considerably in excess of this.

Manufacturers of the lead battery state that 110 deg. F. is the limit. If a battery temperature gets up to that point stop further charge or discharge until it cools. If it goes above that temperature it is not only liable to sulphate the plate, but may cause the active material of the plate to disintegrate.

Prob. 46. Why is it that a warm battery will charge at a lower rate and give a higher rate on discharge than a battery at normal temperature will?

Ans. 46. As explained in Prob. 34, published last month, whenever a charging current flows in the battery there will be a corresponding flow of sulphate from the active material into the electrolyte and vice versa on discharge. This flow of sulphate from the active material into the electrolytic is a combined chemical and physical operation. That is, there must be an actual flow of acid either in or out of the plates, as the case may be. This is accomplished by what is commonly known as diffusion. It is well known that the diffusion of two liquids takes place much more readily in warm temperature than it does in cold temperature, hence the battery action, so far as diffusion is concerned, will go on more readily, both on charge and discharge, when the battery is warm than when it will when it is cold. This will permit the battery to give a higher voltage on discharge and require a lower charging voltage when operated warm than it will when operated at normal temperature.

The ohmic resistance of the battery is also lower when warm than when at normal temperature and the electro-motive force, generated by each plate, as explained in Ans. 34, is slightly greater in a warm battery than in a normal battery. Therefore, all of these factors taken together cause the warm battery to charge at a lower voltage and discharge at a slightly higher voltage than a battery at normal temperature will.

Prob. 47. Why will a battery that is extremely cold, say around zero degrees F., require a charging voltage considerably higher and give a discharge voltage considerably lower than the same battery would at normal temperature?

Ans. 47. Again referring to Prob. 34, published last month, the same elements affect the voltage delivered by a storage battery at low temperature. (1) The electro-motive force generated will be slightly less because of weakened electro-chemical action between plates and electrolyte due to the low temperature; (2) The ohmic resistance of the battery will be greater because the electrolyte is cold; (3) But the main reason is that the diffusion of the electrolyte, either in or out of the plates, will take place less rapidly than when at normal temperature. This will increase the polarizing effect, as explained in Prob. 34. All these effects combine to make the voltage in discharge low and the charging voltage higher at low temperature than at normal.

Prob. 48. Can the electrolyte of a lead battery freeze? What happens if it does?

Ans. 48. Sulphuric acid electrolyte of 1,200 specific gravity will freeze at 70 deg. F. below zero. When this occurs the diffusion of sulphate mentioned above then becomes entirely impossible, so the battery cannot deliver any current whatever until it warms up sufficiently to melt the electrolyte.

Prob. 49. What causes the specific gravity of a battery to rise as the battery becomes charged and to fall as the battery discharges?

Ans. 49. As explained in Prob. 34, there is a transfer of sulphate from the active material of the plates into the electrolyte when the battery is charged and when it is discharged, the sulphate goes back again from the electrolyte into the plates. When this sulphate is in solution in the electrolyte it increases the density of that electrolyte and makes it of a higher specific gravity. On the other hand, when the electrolyte is weak in sulphate, due to this sulphate having gone into the plates upon discharge, it becomes less dense and is of a lower specific gravity.

Prob. 50. Why does it take a higher voltage to force 40 amperes through a car lighting battery at the end of charge than it does at the beginning?

Ans. 50. As explained in Prob. 34, published last month, the charging current at the beginning of charge has a comparatively easy job in breaking up the sulphate combination with active material on the surface of the plates. After the charge has proceeded for a long time, however, all of the sulphate on the surface of the plates, and in for considerable depth, has been reduced and driven out of the plates, the current must then act on the sulphate combination deep down in the plates, and as explained in previous problems, the diffusion of electrolyte is then slower and it takes a higher potential to force the action.

Prob. 51. What causes a battery to gas, and why does it gas at the end of charge and not at the beginning?

Ans. 51. Electricity, like a good many human beings, always does the easiest thing—it always flows most along the path of least resistance. The battery does not gas at the beginning because it is easier to break up the sulphate combination in the plates than it is to decompose water (the cause of gasing). At the end of charge, when the sulphate combination is all decomposed and sulphate all driven out of the plates, there is nothing left for the electricity to do but to decompose the water in the electrolyte. This, however, requires a slightly higher voltage.

Prob. 52. What causes a storage battery to explode sometimes when a light is brought near?

Ans. 52. When a battery gases it decomposes the water of the electrolyte, forming hydrogen at the negative pole and oxygen at the positive pole. These two gases, when mixed in the proportion that they are given off by the battery, form a very explosive mixture. In exploding they simply recombine, forming water again.

Prob. 53. Is it necessary to make a battery gas when charging it?

Ans. 53. Recent battery practice in charging batteries at constant potential has proved that it is not necessary to gas the battery in order to fully charge it. Several axle lighting equipments are now being operated at a constant potention of 2.23 volts, which is below gasing voltage of the battery, hence no gas is formed. Several months' experience has shown that this potential is sufficient to keep the batteries fully charged.

Prob. 54. Does excessive gasing of the battery injure the plates?

Ans. 54. Excessive gasing in plates does tend to injure them, for this gas is formed in the body of the plates as well as on the surfaces, and mechanically blows out the active material; the buffers of gas rising to the surface also mechanically brush active material off the plates forming mud in the bottom of the tank.

Prob. 55. Is it necessary to give a storage battery an overcharge occasionally?

Ans. 55. The lead battery manufacturers, a few years ago, recommended that all batteries be given an occasional overcharge. Experience of the past year, however, with axle equipments operated at 2.23 to 2.3 volts per cell has proved that this overcharge is not absolutely necessary.

Problems for Next Month

Lead Storage Battery Questions Continued.

Prob. 56. What is meant by giving a battery a taper charge?

Prob. 57. Can this be produced on an axle equipment?

Prob. 58. What are the different methods by which you can tell when a storage battery has been brought up to full state of charge?

Prob. 59. Are all of these methods reliable?

Prob. 60. Can any of them be employed for automatically controlling the charge given a storage battery by an axle lighting generator?

Prob. 61. What was the reason that the voltage coil, "stop charge relays" have proved so unsatisfactory in car lighting service?

Prob. 62. Has the ampere hour meter method of controlling battery charge been used successfully to any extent on axle equipments?

Prob. 63. Can the ampere hour meter be used for automatically controlling the charge given storage batteries on the various cars of a train being lighted by the head end system? If so, how?

Prob. 64. Does overcharging a storage battery injure it?

Prob. 65. Can you tell from the appearance of the battery if it is regularly receiving too much charge?

Prob. 66. What percentage overcharge in ampere hours should be given a storage battery in order to make up for battery losses and to keep the battery in a full state of charge?

Prob. 67. Is the ampere hour meter mechanically strong enough to stand the severe conditions of car lighting service?

Prize Question Box

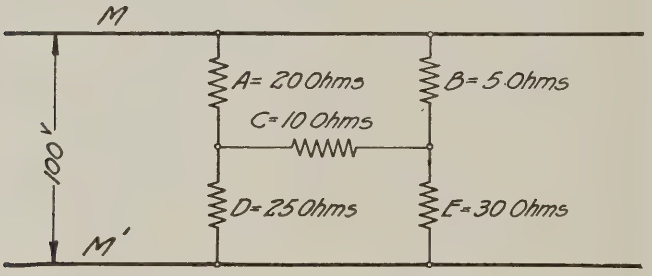
This "Question Box" is open to every electrical man in the Mechanical, Signal and Telegraph, as well as Car Lighting Departments. We feel that this can be made a mighty valuable thing, so as a special inducement to the boys to boom it, we offer prizes for the best questions asked, as follows:

First prize	$1.00 *in cash*
Second prize	9 *months' subscription*
Third prize	6 *months' subscription*

There are some questions that are of a general nature, which should have comments of prominent men of experience. These will be published under "Questions Before the House," and we hope that prominent railroad men and manufacturers will discuss these questions. All answers published will be paid for at $1.00 *each.*

Solving Complex Circuits

In applying Ohms Law to the solution of divided circuits I came upon the following problem which I would like to know how to solve. In the accompanying figure, assuming a potential of 100 volts between the wires M M', what current will flow in each of the 5 branches, A. B. C. D. & E. f their respective resistances are 20-5-10-25-35 ohms.



Fred Loweth, Buffalo, N. Y.

Solution of Problem Above

The principle by which any complex circuit is solved is that the resistance drop in a circuit is equal to the impressed voltage in that circuit, in other words, the current multiplied by the resistance in each branch of the circuit is equal to the voltage across that branch.

Now assuming that M is positive. The current in A, B, D and E will be downward, and the current in C from right to left. Now let the current in each branch of the circuit be represented by the letter designating that branch. The current in D then equals A plus C, and the current in E equals B minus C. The voltage drop through A and D then is:

$$20A + 25\ (A + C) = 100 \text{ volts}, \quad (1)$$

and through A, C and E is

$$20A - 10C + 30\ (B - C) = 100 \text{ volts}, \quad (2)$$

and similiarly,

$$5B + 30\ (B - C) = 100 \text{ volts}, \quad (3)$$

and

$$5B + 10C + 25\ (A + C) = 100 \text{ volts}, \quad (4)$$

$$\text{From (1) } A = \frac{100 - 25C}{45} \quad (5)$$

$$\text{From (3) } B = \frac{100 + 30C}{35} \quad (6)$$

Substituting in (2) and solving

$$C = 1.20 \text{ amp.}$$

$$\text{From (5)} \qquad A = 1.56 \text{ amp.}$$

$$\text{From (6)} \qquad B = 3.88 \text{ amps.}$$

$$D = A + C = 2.76 \text{ amps.}$$

$$E = B - C = 2.68 \text{ amps.}$$

C. D. S.

Temperature Coefficient of Wires.

Ques. Is there a conductor of any description, the resistance of which decreases as the temperature rises?

Ans. Carbon is the only known element, the resistance of which decreases as it warms up. Nearly all metals have a positive temperature coefficient, that is, the resistance increases with a rise in temperature. The amount of increase in resistance, however, varies with different metals, for instance, the resistance of an iron wire increases about 50 per cent more for a certain rise in temperature than a copper wire does. Moreover, certain alloys of metals have a zero temperature coefficient, that is, the resistance is the same at all temperatures. A wire of the following composition is of this class: copper 84 per cent, manganese 12 per cent, nickel 4 per cent.

System of Handling Repairs to Axle Equipment.

No. 7. What is the best method of handling repairs to axle devices? That is, is it better to make repairs on each device enroute or at terminals as soon as the trouble develops or, by having a few spare equipments, simply replace the complete board or the complete generator which is giving trouble and make the necessary repairs in the shop?—L. S. Billau.

Axle Generator Troubles.

In motoring a type "A" Consolidated dynamo recently the dynamo would make an attempt to motor in the same direction immaterial of the position of the pole changer, and in each case the main fuse would blow. In connecting the generator afterwards, the positive and negative generator leads became reversed and the machine immediately started motoring with the auto switch closed and the main fuse out. Was this due to the generator being grounded? —G. B.

Ampere Hour Meters in Car Lighting Service.

What attention has it been found necessary to give ampere hour meters in car lighting service to maintain them properly? How frequently should they be removed from cars and taken into shop for thorough overhauling?—L. S. Billau, B. & O. Ry.

Commutator Short in Wave Wound Armature

When testing a four pole wave wound armature for short-circuited commutator segments with a telephone receiver, a curious result was obtained. Not only was a short indicated at the point of the actual short circuit but also at the opposite and quarter points on the armature.

Why did the telephone receiver indicate shorts at these four points?

G. B. Billings, Topeka, Kans.

Generator Grounded Field Coil in Moskowitz.

No. 10—While motoring a Moskowitz generator, the automatic switch, after being closed, had a tendency to stick quite tightly in position and immediately release, in the same revolution of the armature. This effect was maintained as long as the switch was held in the operating position. In motoring this machine in the opposite direction, it was found to work perfectly. After carefully looking over the generator, it was observed that one field-coil was grounded. After removing the ground, the auto switch worked perfectly in either direction.

What caused the automatic switch to act in this manner? Why did the grounded field coil effect its operation only in one direction?—H. W. Millard, Santa Fe.

Ground on Type "K" Relay.

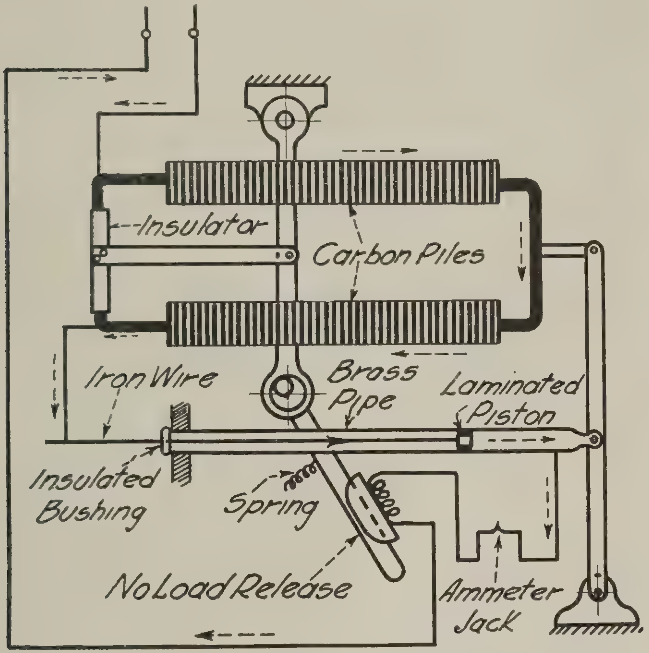
What effect will a ground on a type K relay have on the operation of the U. S. L. equipment?—Frank M. Burke, Pullman Co., Jersey City.

Practical Stunts

We Pay a Dollar Apiece for Practical Stunts—Send in Your Ideas

Automatic Rheostat for Battery Charging.

By means of these home made rheostats we have been able to control the battery charging current very effectively. The operation of this rheostat is as follows: The two carbon piles are in series with the brass tube; the current flows from the carbon piles through the iron wire, out then through the piston to the brass pipe, the ammeter jack, and the under load released to the outlet of the rheostat. The heat given off by the iron wire heats the brass tube and causes it to expand. This moves the lever arm at the right, releasing the pressure on the carbon piles, which cuts down the current, thus keeping the current constant. This constant value may be either increased or decreased accordingly, as the iron wire and piston are moved to the left or to the right.



Automatic Rheostat for Controlling the Charging Current to a Constant Value

The underload release is merely a series coil holding the underload release lever in place. When the current falls to a certain value the arm is released and the pressure on the carbon pile is removed from the left, breaking the circuit.

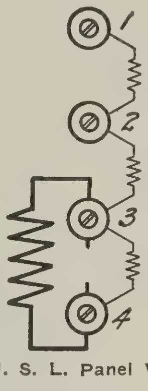
Fire Proofing Wood.

There are quite a number of mineral salts, such as alum or borax, which can be used for fire proofing wood; but the chief trouble heretofore has been with impregnating the wood with the salt. Painting it will simply cover the outer surface, as the sap in the wood will not let any solution penetrate far. If the wood to be treated is fastened to a lead plate connected to the positive pole of either a battery or dynamo and placed in the bottom of a tank, and the negative plate suspended in the tank, when the current is turned on the sap rises slowly upward to the negative plate and the solution of borax takes its place. A little resin and carbonate of soda are said to make the borax solution more effective.—Charles Baron.

Current Adjustment on Type "C" U. S. L. Panel.

At the present time when so much attention is being paid to the charging rate of batteries accurate control is essential. The normal current adjustment with the U. S. L. panel may be supplemented by a resistance wire, as shown. With the short circuiting pin out, 30 amperes will flow, with the pin short circuiting poles 1 and 2, 43 amperes will flow. We have used a resistance to substitute between 1 and 2 consisting of seven turns of No. 9 resistance wire. By this means we obtained a current of about 37 amperes. By having the proper resistances on hand the current can be made to vary anywhere between 30 and 43 amperes.

H. G. Myers, Santa Fe.



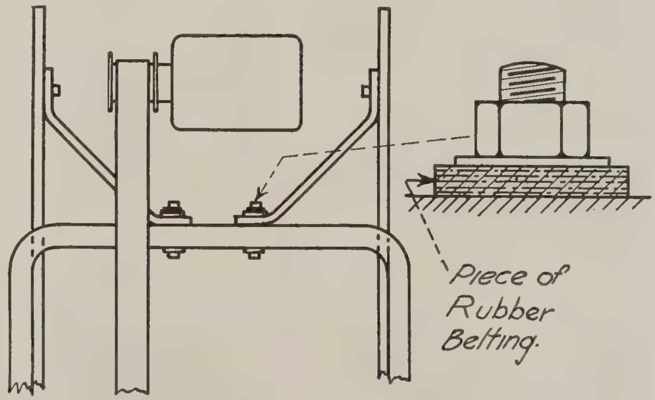
Adjusting Resistance of U. S. L. Panel With Auxiliary Resistance

---

Old Belt Repairs Loose Frame Bolt.

We have sometimes experienced considerable trouble in keeping the bolts tight on steel trucks at the point where the brace is fastened to the end sill. By using a piece of old belting as a washer, as shown in the sketch, this difficulty has been entirely obviated.

Clyde Stewart, Santa Fe.



Showing How It Is Possible to Get Any Current Setting Desired on Type C—U. S. L. Panel

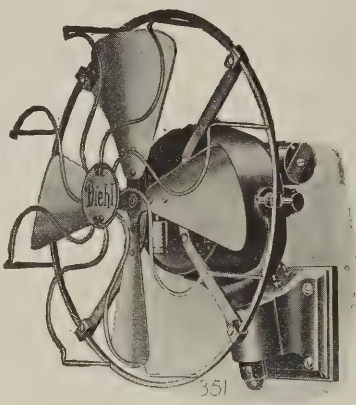
---

Test for Grounds.

While in the yard recently I came across a car with machine not working properly. I did not have a magneto

The House

Our ability to make immediate shipment from an immense
to your orders. Your entire requisition for electrical
one order and you receive the goods in one shipment. Think



Diehl Car Fans, pleasing in design, give a finishing touch to passenger comfort. They have been designed especially to meet the severe conditions of railroad service. The fan body is readily removed from the base without disturbing the wiring. Furnished in all standard voltages and also 30-60 volt combination. In ordering specify voltage.

DELTABESTON WIRE REG. U.S. PAT. OFF.

"Deltabeston" Magnet Wire

is used by many roads for rewinding fields and armatures of

Electric Headlights

The insulation is pure asbestos fibre, impregnated.

It won't burn out.

Neither is it affected by moisture.

Can be supplied in all sizes; either flat or round.

Central Elect

320-326 S. Fifth Ave. "The House

# of Service

stock of the best electrical material ensures prompt attention supplies on any job, no matter how large, can be covered with of the convenience!

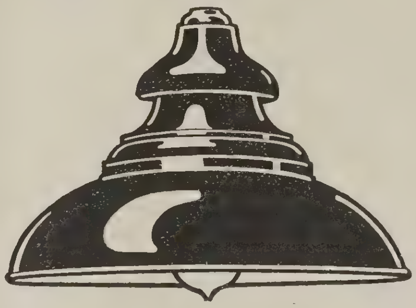
OKONITE

TRADE MARK.

Insulated wire for railway signals, car lighting, shop and terminal light and power service must be absolutely dependable and have the highest insulating qualities — this is just another way of specifying Okonite. It has for years been the standard in railway service.

Okonite Insulation contains never less than 30% of the best quality dry, fine, up-river Para rubber and is made in but one grade, only—**The Best.**

The MAXOLITE



For

Type "C" Lamps

A *one piece* ventilated Maxolite with type "R" fitting.

For use in

Shops	Trainsheds
Yards	Roundhouses
Platforms	Warehouses

Ask for Bulletin 43

ric Company

of Service" Chicago

with me so slacked off on tension rods enough to motor machine, went to electric light locker and blocked automatic switch, and by shortening my screwdriver across the housing of machine and brush rigging of pole changer, found heavy spark.

This is a simple form of testing, but it not only catches a ground on the machine, but batteries, lights, fans and the entire electrical device.

C. B. Franklin, Pullman Electrician.

No More Loose Battery Connectors.

In order to obviate the trouble from loose connections we have found it good practice to burn the connectors to the battery post. This is done by holding the connector on to the post and then burning them together with a carbon arc. No arc is drawn in reality but the lead is melted by the heat developed in the carbon conductor. The current is supplied by the set of batteries being repaired. If the batteries have just been on charge the gases are first blown out with compressed air. The connectors between crates are left long enough so that each crate can be lifted from the truck to the car without disconnecting. If it is necessary to separate the units the connection is broken in the middle and connected with brass connectors and a 1 in. battery bolt.

H. G. Myers, Santa Fe.

Nitrolite Jingle Contest.

The Harter Mfg. Co. offered a $5.00 prize to each of the three best poets submitting a verse or two on the nitrolite. This stirred up considerable interest at the convention time, and Messrs. Meloy, Causland and Andreucetti, acting as judges, awarded prizes to Mr. C. B. Gallagher, of the I. C. R. R., Memphis, Tenn.; Mr. T. H. Hopkins, of the I. C. R. R., Louisville, Ky., and Mr. W. J. Flynn, of the C. & N. W. R. R., Chicago.

U. S. L. Notes

Mr. R. E. Stuntz has been appointed manager of the Chicago branch of the U. S. Light & Heating Co.

Mr. H. A. Matthews has been appointed western manager of the car lighting department of the U. S. Light & Heating Co., headquarters at Chicago.

Mr. A. N. Donop has been transferred to the sales department of the Chicago branch of the U. S. Light & Heating Co.

Willard Chicago Office Notes.

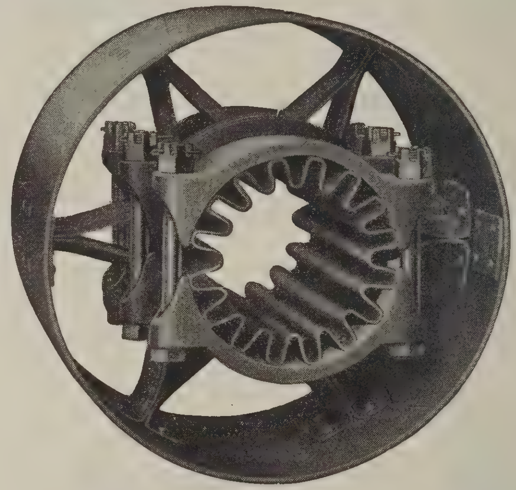
Mr. J. S. Shutes and Mr. N. G. Wolf, both formerly with the Rock Island at Chicago, have joined the Chicago office of the Willard Storage Battery Co. Both men are well known among the car lighting boys, Mr. Wolf having been recently Assistant Chief Electrician of the B. & O. C. T.

New Maxolite Catalogue.

A new booklet has just been issued by the Central Electric Company of Chicago, entitled "Maxolite." This describes the new type "R" fitting applied to various types of indoor and outdoor lighting units. It is made in all sizes to accommodate 150 to 1000 watts nitrogen filled lamps. Units are so designed as to make their installation extremely simple. All units are well ventilated and the line includes ornamental diffusing bowls for auditorium and store lighting, copper finished pendant units, porcelain enamel reflectors, for industrial use, etc. Copies of the bulletin may be had upon request.

KEYSTONE
Railroad Axle Pulley
MANY THOUSANDS IN USE

Looks Good, Don't It?

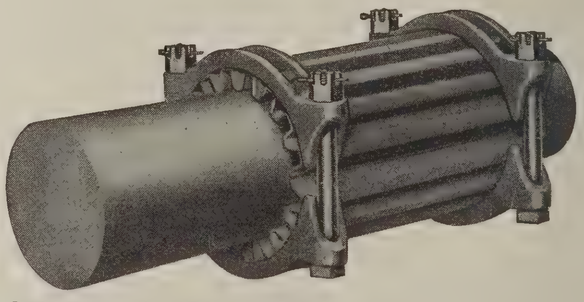


Keystone Railroad Pulley With Oneida Corrugated Bushing
Patented January 8, 1907

The Keystone Pulley
with Oneida steel
Corrugated Bushing

is the best combination for car axle lighting on the market.

Pulley made flange or flangeless. Standard 7½-in. bore, 16-in. to 23-in. dameter inclusive. Write for booklet.



Oneida Corrugated Steel Bushing Made to Fit Straight or Taper Axle
Patented January 8, 1907

Oneida Steel Pulley Co.
ONEIDA, N. Y.
The Originators of Steel Railroad Pulleys and Steel Corrugated Bushings

RAILWAY ELECTRICAL ENGINEER
Official Journal
of the Association of Railway Electrical Engineers.
PUBLISHED MONTHLY BY
WRAY PUBLISHING CO.
EDWARD WRAY,
President.
C. D. SPERRY.
Assoc. Editor.
ADVERTISING BLDG.—123 W. MADISON ST.
CHICAGO.
Telephone, Randolph 7414.

Entered as second-class matter, August 6, 1909, at the Post Office at Chicago, Ill., under the Act of March 3, 1879.

TERMS OF SUBSCRIPTION
United States, Canada and Mexico - - - Per Year, $1.00
Foreign - - - - - - - - - Per Year, $1.50

Table of Contents

Editorials— Page
Headend Versus Axle Car Lighting Systems........225
Electrification of Mountain Division C., M. & St. P. R. R.........225
Electrification of Mountain Division C., M. & St. P. R. R.226
The Lighting of Railway Yards with Large Incandescent Units.—L. C. Doane........228
Gas Electric Motor Cars........232
Semi-Outdoor Portable Substations........233
Electric Lighting—A Factor in Civilization........236
Shop Motor Section........239
Railroad Electricians' Club........240
A. B. C. Car Lighting Course........243
Prize Question Box........245
Practical Stunts........247
With the Manufacturers........248

Headend vs Axle Car Lighting System

Another contest between the headend turbine and the axle generator for car lighting has just been decided on the B. & O. Railroad in favor of the latter system, as announced in another part of this issue. This road has for several years been lighting four of its through trains between Chicago and New York with the headend system. On account of the inflexibility and high operating costs under the conditions experienced on this road, it has been decided to discontinue the use of this system in favor of the 30-volt axle generator car lighting system.

The B. & O. Railroad is the last of a number of eastern roads who have thoroughly tried out the headend system and found that it did not meet their operating conditions as well as the axle generator or straight storage car lighting system. The fact that there are a number of large western roads lighting their cars by the headend system with perfect satisfaction and great economy might seem rather paradoxical in the light of the experience of eastern roads. This only shows, however, that conditions greatly alter circumstances.

On the B. & O. Railroad and most other eastern railroads there are frequent division points at which cars are switched in or out the train. This requires a comparatively large auxiliary of storage batteries to maintain the cars lighted. On the other hand, on many western roads most of the trains run as a solid block from one terminus to the other, in many cases even carrying the dining car throughout the entire trip. Moreover, it is usually found that on the western roads the through trains are comparatively longer than those on the eastern roads and, as it costs but little more to light a train of 12 cars than it does a train of 6 cars by the headend system, the unit cost per car for this system of car lighting on western roads should be correspondingly less.

Therefore this action by the B. & O. Railroad in abandoning the headend system cannot be taken as any wide sweeping argument against the headend system under all circumstances; on the other hand, those roads that now operate the headend system to their entire satisfaction, must realize that conditions exist on the B. & O. which are far different from those on western roads and which make the headend system impractical under operating conditions in the east.

Electrification of Mountain Division C. M. & St. P. R. R.

Plans of the Chicago, Milwaukee & St. Paul Ry. for the immediate electrification of a mountain division over 100 miles long is another evidence of the fact that the electrification of railroads is now feasible strictly on the basis of economic considerations without any reference whatsoever to exigencies of tunnel or terminal conditions. The electrification of a division between Deer Lodge and Three Forks, as described in another part of this issue, is the first step in a vast scheme of electrification covering the entire mountain and Pacific Coast division of this road. Plans for the near future will extend this electrified zone to approximately 440 miles of main line track with the ultimate electrification of all mountain and Pacific Coast divisions, covering a distance of 865 miles.

No doubt one of the factors influencing this road to electrify so extensively in this region is the presence of cheap hydroelectric power along the entire route. This will be furnished at appproximately one-half cent per kw. hour with certain regulations for power factor and maximum demand. The cost of the first division to be electrified will be approximately $3,000,000 and, with the 440 miles electrified, $12,000,000, but conservative estimates show a saving in operating costs of 25% over the costs involved in present system of operation.

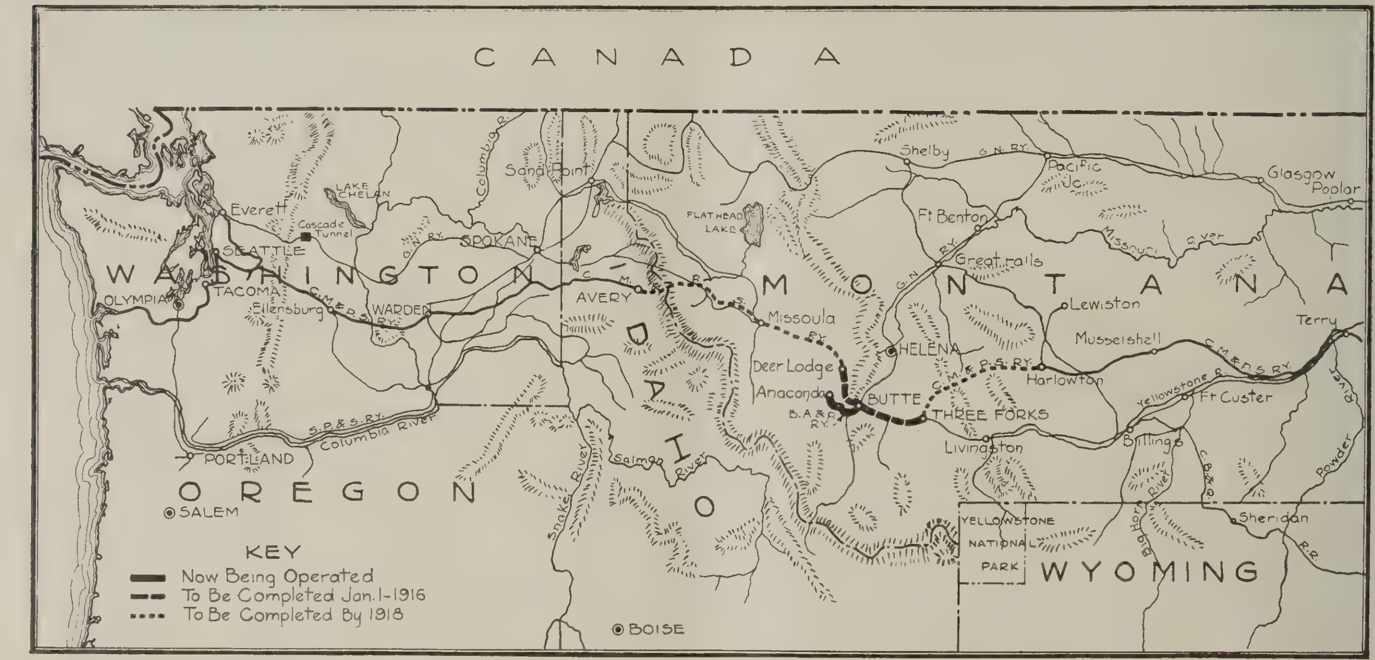
The installation is not only noteworthy for its length of main line, but the locomotives to be used will be the heaviest and most powerful electric locomotives ever built. In the locomotive design particular consideration has been given to the effect of vertical and horizontal tresses on track, road-bed and bridges, caused by the locomotive traveling at high speed. The entire weight of the locomotive, 260 tons, is stretched out over a length of 112 ft. 8 in., so that the localized stresses on the track due to the passing of such a powerful locomotive, are minimized. Each driving axle is equipped with a motor of 375 h. p. and twin gear drive.

The operation of this electrified section, which is expected to be in service by January 1st, 1916, will be watched with a great deal of interest by all railroad officials.

Electrification of Mountain Division, C. M. & St. P. R. R.

On November 13th the Chicago, Milwaukee & St. Paul R. R. placed a contract with the General Electric Company to furnish the electrical equipment for the proposed electrified division between Three Forks and Deer Lodge. This contract is for the electrical equipment complete, consisting of twelve locomotives, overhead line material, and four substations.

This division is 113 miles long, and the details of the design will be very similar to those of the Butte, Anaconda & Pacific, which is a branch of this road. The features of the construction of the B., A. & P. were described at length in the March and August issues of the Railway Electrical Engineer.



Map Showing Existing Electrification as Well as Plans for the Present and Near Future.

It is estimated that the labor and material necessary to complete the first 113-mile division will cost approximately $3,000,000. It is also estimated that the complete electrification, comprising 440 miles, will cost approximately $12,000,000, but the change in motive power is expected to result in a saving of 25 per cent over the costs involved by the present system of operation.

With regard to route mileage this electrification is the first step in a scheme which, when completed, will very greatly exceed anything that has heretofore been attempted. The immediate program calls for the electrification of 113 miles of line between Three Forks and Deer Lodge, Mont., as shown in the accompanying map. This, with sidings, makes a total single-track mileage of 168. The plans for the near future, however, include the extension of the electrified zone to cover 440 route miles between Harlowtown, Mont., on the east, and Avery, Idaho, on the west, the whole foreshadowing the ultimate electrification of the main line to the Pacific Coast, a distance of 865 miles.

The noteworthy thing about this announcement is that the electrification was not made necessary because of nuisances caused by the steam railroad, such as smoky tunnels or congested terminals. It was brought about because of the economies that can be effected by the substitution of the electric for steam power. The presence of cheap hydro-electric power undoubtedly was a factor in electrifying this section.

In authorizing the statement that the final contract for the work had been closed, C. A. Goodnow, assistant to the president, in charge of construction, Chicago, Milwaukee & St. Paul Ry., said that field work on the overhead line would be started as soon as forces could be organized. Practically all of the poles are on the ground at the present time, and the overhead line material will be available as rapidly as it is required. The contract calls for the delivery of the first substation equipment on May 1, 1915, and the first locomotive on October 1, 1915. Upon receipt of the first locomotive it is planned to run an operating test, and, if this is satisfactory, the electrified division will be in full operation by January 1, 1916.

Overhead Construction.

There is one difference between the pantograph construction of the Butte, Anaconda & Pacific, and that which will be used on the new electrification. On the former road a roller pantograph is used, but in the present case a shoe pantograph will collect the current. This form of collector has found considerable use in Europe, but up to this time has not been tried out in this country. The contact wires will be supported by a flexible catenary construction that will be hung from mast arms on wooden poles, the single-pole bracket construction having been adopted because it affords a minimum obstruction to the view, and also is less expensive than the use of span wires. Double poles with span wire, however, will be employed where there are two or more tracks, as well as at the sharper curves.

A limited amount of feeder copper will be placed on the poles at the present time to minimize the voltage drop between substations. A high-tension transmission line will also be installed along the right-of-way, tying the substations together. This line will be erected and maintained by the railroad company, independently of the transmission lines from the hydroelectric company which is to supply the power, and it will form a ring system to protect against shut-downs through the line failures.

The prime power will be purchased from various hydroelectric plants of the Montana Power Company, and it will be transmitted to the railway company's four substations at 110,000 volts, three-phase, sixty cycles. The price at which it will be furnished approximates ½ cent per kilowatt-hour, the power factor being limited to a variation of 20 per cent from unity and the monthly load factor being the equivalent of 60 per cent when based on the contract load. As planned at present, the load factor will easily be maintained by requiring the dispatcher to adjust train movements so as not to exceed the maximum amount of power covered by the power contract.

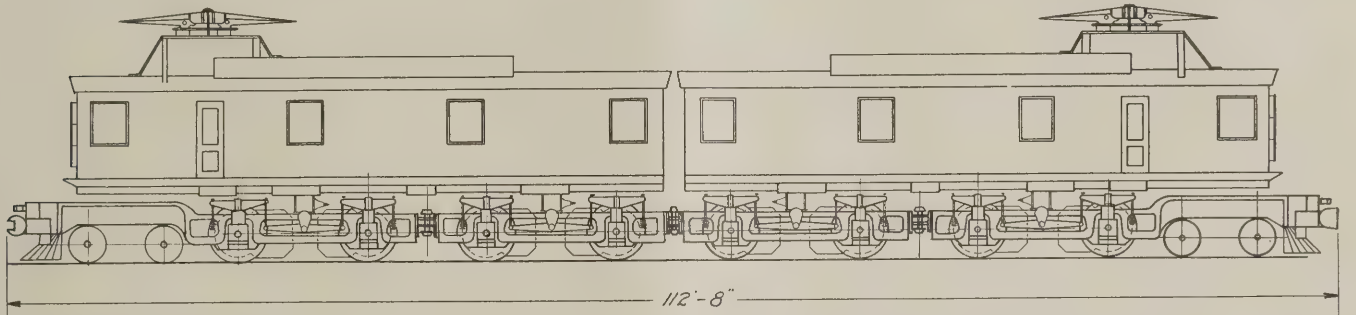
Substations.

The high-tension alternating current will be transformed to 3,000 volts d. c. in four permanent substations. These will be built of brick, and will have concrete roofs that will provide a support for overhead high-tension busbars. Indoor transformers, of the self oil-cooled type, will step down the high-tension current to 2,300 volts a. c. for use in motor-generator sets, each of the latter being composed of a synchronous motor mounted on the same shaft, with two 1,500-volt d. c. generators that are connected in series to supply 3,000 volts to the line. Each unit will have two separate exciters for the synchronous motor and for the generator fields, and, with the control switchboard and transformers, will make a complete independent set.

Two of the four substations that will be installed for the 113-mile division will contain equipments consisting of three 1,500-kw. motor-generator sets, and each of the other two substations will be equipped with two 2,000-kw. motor-generator sets. The total substation capacity will thus be 17,000 kw. or about 50 per cent of the input of all of the locomotives, the reason for this relatively high percentage being the high requirements for starting trains which reach momentary peaks of more than 5,000 kw. These momentary loads will be easily carried, however, by the five-minute overload capacity of the motor-generator sets, which will be of the order of 200 per cent. The substations will be erected and placed in operation by the railway company, the General Electric Company furnishing all of the electrical machinery.

Locomotives.

The locomotives, of which twelve are to be included in the initial installation, are truly remarkable for their size and power. Each will consist of two half-units permanently coupled together to make an engine 112 ft. 8 in. long that weighs 260 tons, and that has 200 tons on drivers. The prominent feature of the design is the use of a separate motor twin-geared to each of the eight pairs of driving wheels. In the design may be seen the principle of "stretching out" the locomotive, and thus minimizing the localization of vertical and horizontal blows on the track. The same principle was followed, although on a much smaller scale, in the case of the latest type of high-speed electric locomotive built by the General Electric Company for the New York Central Railroad, these engines having made a remarkably successful record for the past year in hauling the extremely heavy through passenger trains on that road.



Double unit type of electric locomotive for mountain division of C., M. & St. P. R. R. Note that each axle is equipped with an individual motor and the four-wheel driving trucks are flexibly connected by permanent couplings.

The eight pairs of drivers for each complete locomotive are equally spaced at about 10-ft. intervals. Each half-unit has two articulated trucks with frames outside of the driving wheels, and this arrangement, together with the connection between the half-units themselves, provides a chassis composed of four trucks linked together by three permanent couplings. The driving-wheel trucks at the extreme ends of the complete unit have their frames extended to provide center-pin castings for four-wheeled bogie trucks, the extended framing carrying also the bumper beams and coupler at each end of the locomotive.

A summary follows of the general dimensions and weights of the locomotive:

Length face to face of couplers	112 ft. 8 in.
Total wheelbase	103 ft. 4 in.
Wheelbase each half unit	45 ft. 7 in.
Minimum driving wheelbase	5 ft. 0 in.
Total weight	260 tons
Weight of drivers	200 tons
Weight on each pair of driving wheels	25 tons
Weight on each bogie truck	30 tons
Diameter of driving wheels	52 in.
Capacity of locomotive—continuous rating	3000 h. p.
Capacity of locomotive—our-hour rating	3440 h. p.

Motors and Control.

The eight motors for the complete locomotive will be of the General Electric No. 253-A type, and each will have a continuous rating of 375 hp. and a one-hour rating of 430 hp. This will give the locomotive a continuous rating of 3,000 hp. and an hourly rating of 3,440 hp. The drawbar pull effective for starting trains will approximate 80,000 lb. As previously mentioned, the motors will be twin-geared to the driving axles, that is to say, each armature shaft will carry a pinion on each end, and it is only in the matter of gear ratio that the passenger locomotives will differ from those used for hauling freight.

The motors will be insulated for 3,000 volts, but they will be permanently connected in pairs in series, so that the voltage across each one will be 1,500 when the locomotive is operating in full parallel on the 3,000-volt trolley. The control will provide three running positions with the four pairs of motors connected in series, series-parallel or full-parallel, but the control system will include the novelty (for this country) of using regenerating braking control for holding trains on down grades. This will provide also for regenerative return of energy to the trolley wire on long down grades, so that the presence of a train going down a mountain grade will be of assistance to another train coming up. This obviously will improve the load factor of the electrified division to a marked degree.

The motor equipment will enable locomotives in freight service to pull 2,500-ton trains up 1 per cent grades at a speed of 16 m. p. h. or, when two locomotives are used on a train will provide power enough to pull 2,500 tons up a 2 per cent grade. However, the plan of operation includes the general use of a locomotive at each end of trains on ascending grades, there being one 2 per cent grade 20 miles long and two 1 per cent grades approximately 35 miles long on the electrified section. On descending grades only the locomotive at the head end will do the regenerative braking. The locomotives in passenger service will be called upon to haul trailing loads of 800 tons at a speed of 60 m. p. h. on the level.

Collection of the large drafts of current (ranging from 1,500 amp. to 2,000 amp. at 300 volts) that will be required for the service at times will be effected through the use of two pantographs of the "pan" type on each complete locomotive. As a provision against the possibility of injurious arcing, however, and to supply an ample factor of surplus capacity the previously mentioned use of a double trolley wire was considered desirable. This secures flexibility and gives a greater area of collection, the maximum draft of current per pantograph contact being thus reduced to the order of 500 amp.

All of the plans for the electrification project have been in charge of C. A. Goodnow, assistant to the president, Chicago, Milwaukee & St. Paul Railroad, and R. Beeukwes, electrical engineer, and the work of construction that is soon to commence will be under their direction. In general, all of the erection will be done by the railroad company including the installation of the overhead lines, the construction of the substations, and the preliminary operation during the future period of transition from the use of steam to that of electricity.

Lighting of Railroad Yards With Large Incandescent Units

L. C. Doane

The importance of adequate lighting in freight yards and the monetary value of equal ease and accuracy in handling freight both at day and night is well established. The subject of yard lighting has been discussed pro and con for some time passed and the final results to be obtained have been set down in concise form. There are numerous incandescent lighting units on the market, each of which is "the best and most economical."

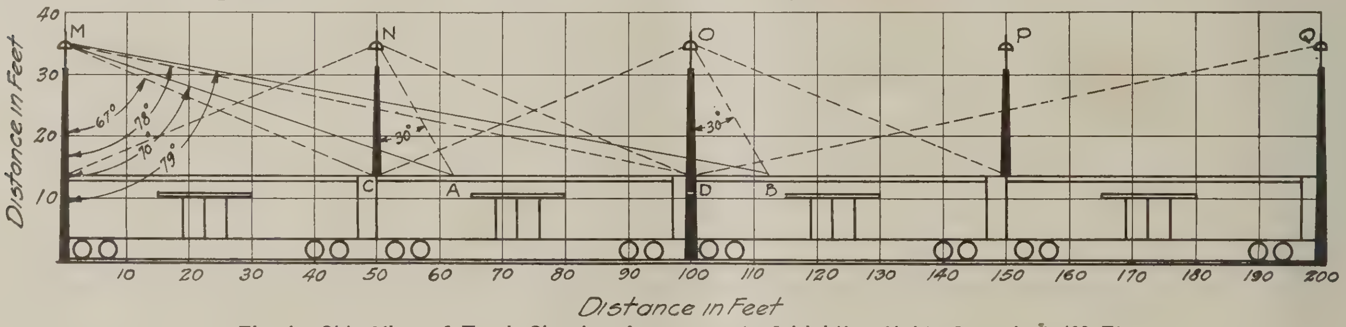


Fig. 1. Side View of Track Showing Arrangement of Lighting Units Spaced at 100 Ft.

The final results that should be obtained are known; the various types of lighting units are known; the different methods of mounting units are known—but there seems to be no data in regard to the connection between those various known points.

The following discussion is intended as a rough analysis of the limitations to properly meeting the requirements for yard lighting and of the possibility of overcoming these limitations by the proper design and location of incandescent lighting units.

General.

The problems of yard lighting have been very well stated by Messrs. H. Kirschberg and A. G. Cotton in their article entitled "Track Scale and Yard Lighting," published in the July, 1914, issue of the *Railway Electrical Engineer.* This article deals particularly with classification yards and scale houses, but is also applicable to other yards to a greater or less extent. Quoting from their paper, the following is a general summary of conditions to be met.

"Many engineers in designing this class of lighting, have considered a classification yard as an open space and have lighted it accordingly. An error of this sort will show, upon reflection, an incompetent consideration of conditions to be met. Quite contrary to this idea, the problem of classification yard lighting may be stated to be more involved than any problem of street or park lighting. A classification yard consists of a series of streets three to four feet wide, with buildings about 14 ft. high on both sides. The ideal system would, therefore, provide light on and between every pair of tracks. How close the ideal may be approached depends upon the alloted appropriation and the desires of the corporation and the designing engineer."

The conditions to be satisfied may be briefly stated as follows:

1. Illumination of the grade leading from the scale to the yard.
2. Illumination of the switches at the head of the yard to facilitate control of car movement from the switch tower.
3. Illumination of every track, irrespective of adjacent car.

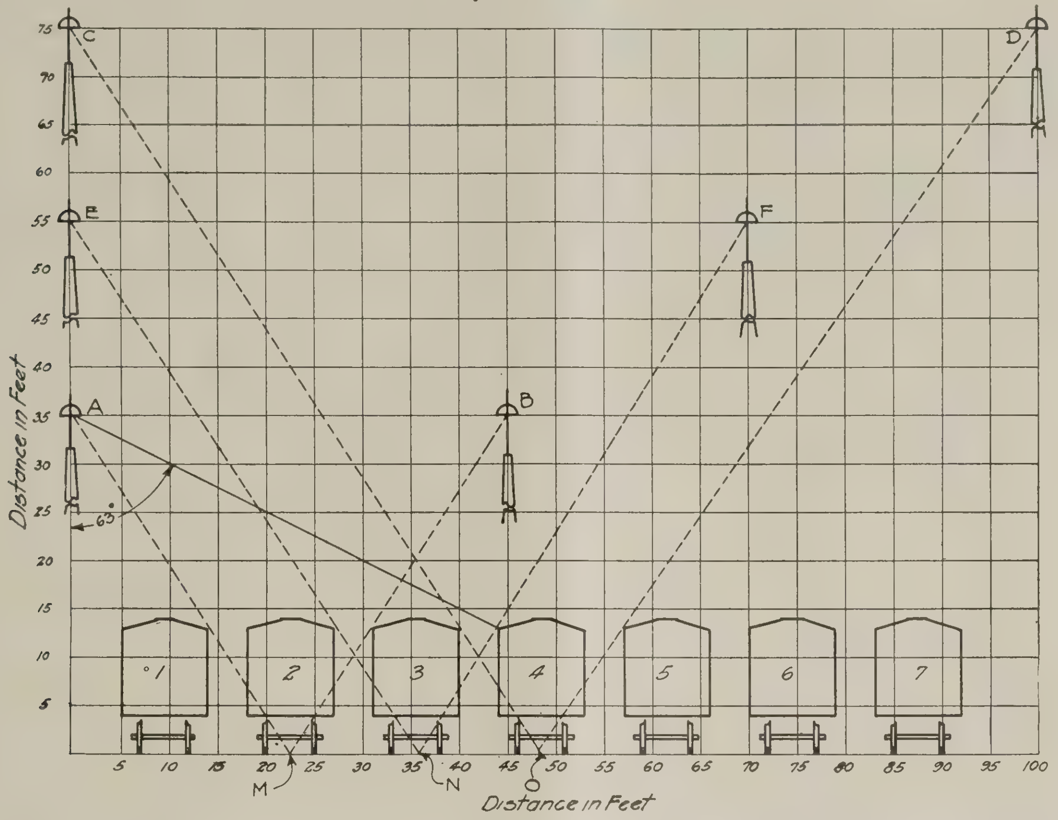


Fig. 2. Typical Cross Section of Yard Showing Maximum Distance Between Rows of Units at Various Mounting Heights.

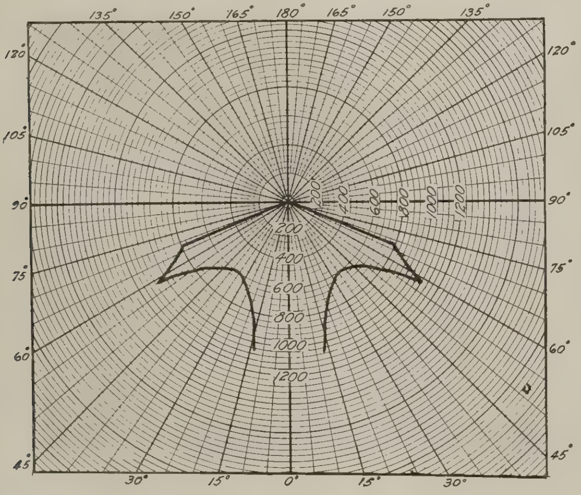


Fig. 3. Ideal Distribution Curve of Units Located at M. N. O., Etc. (Fig. 1) to Give a Uniform Vertical Illumination at the End of Every Car.

4. Illumination of every car in the yard,
5. Absence of glare from every position in the yard.

Yard Lighting Classification and Requirements for Each.

Railway yards may be divided into three general classes. These are—

1. Switching yards.
2. Classification yards.
3. Repair yards.

The requirements for the lighting of the first two classes are of much the same general character and are—

1. Illumination of every track, irrespective of adjacent car.
2. Illumination of every car in the yards sufficiently to determine location and size.
3. Absence of glare from every position in the yard.

The requirements for repair yard lighting are the same as above, with the addition that each car must be lighted evenly from top to bottom and so that no objectionable shadows occur.

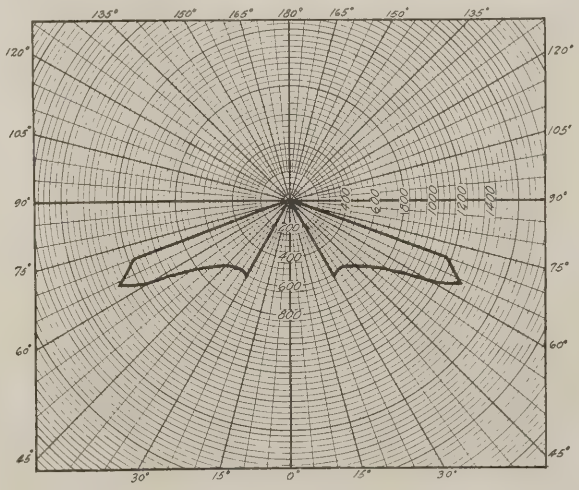


Fig. 4. Modified Ideal Distribution Curve, of Fig. 3, Required to Produce ¼ ft. Candle on Ends of Cars, Mounting Height and Spacing as in Fig. 1, Distance Between Rows 45 ft.

Methods of Mounting Lighting Units.

There are three practical methods of supporting lighting units. These are—

1. Towers.
2. Poles.

3. Catenary construction.

Towers may be built to any height desired, and become cheaper per foot of height as the height is increased (within limits).

Catenary construction is excellent in allowing proper location of units, but is expensive and subject to rapid deterioration.

For wide spacing of units, towers or poles are the most economical. For close spacing of units, catenary construction will be found the cheapest and most satisfactory.

The usual span between poles for distribution lines is about 100 ft. The most economical installation will utilize these poles for supporting the lighting units. This would make a spacing of either 100 ft. or 200 ft. between units and a mounting height of 35 ft. (35 ft. being the greatest practical mounting height on poles).

Spacing Between Rows of Units—Maximum for Good Lighting.

Figure 2 shows the cross section of a portion of a yard with cars fourteen feet high standing on the tracks and with a space of four feet between the sides of the cars.

Position A shows a lighting unit mounted 35 ft. above the ground and with the supporting pole having a 5-ft. clearance from side of car. It is evident that unit A will light track No. 1 satisfactorily and also track No. 2 beyond the point "M." Between track No. 1 and "M," however, will be a heavy shadow. In order to light the space from "M" to track No. 1, it is necessary to place another unit at "B." This then shows the widest spacing that can be made between rows of units when the units are mounted 35 ft. above the ground and when it is desired to have every track lighted, irrespective of adjacent cars. This distance is 45 ft. 0 in.

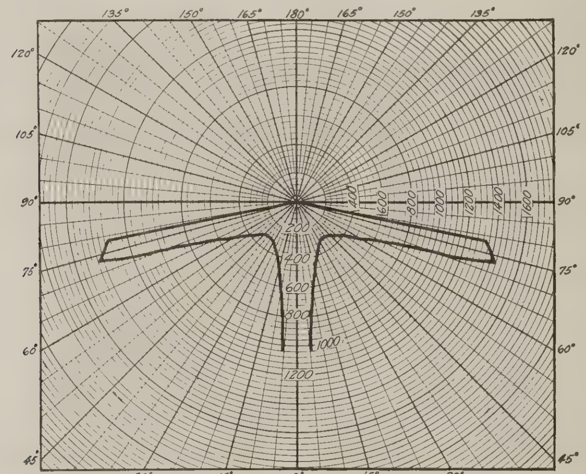


Fig. 5. Ideal Distribution Curve Required to Produce an Even Vertical Illumination of 1/8 ft. Candle With Units Mounted 35 ft. Above the Ground and Distance Between Units 200 ft.

To have the sides of every car lighted, it is necessary for unit "A" to emit light over as far as track No. 4 or up to an angle of 63 deg., for unit B is only useful in lighting one side of the cars on tracks 1, 2 and 3.

Table 1 shows other mounting heights of units and spacing between rows of units that will give the same results as do the spacing and mounting heights of units A and B.

Spacing Between Units in a Row—Maximum for Good Lighting.

Take a longitudinal view of a portion of the yard and assume that the units in a row are spaced 100 ft. apart (the usual pole spacing); have a mounting height of 35 ft.; that adjacent rows are 45 ft. apart and that units are staggered. We then have an arrangement as shown in figure 1. Units M, O and Q are in one row and units N and P are in another row 45 ft. away.

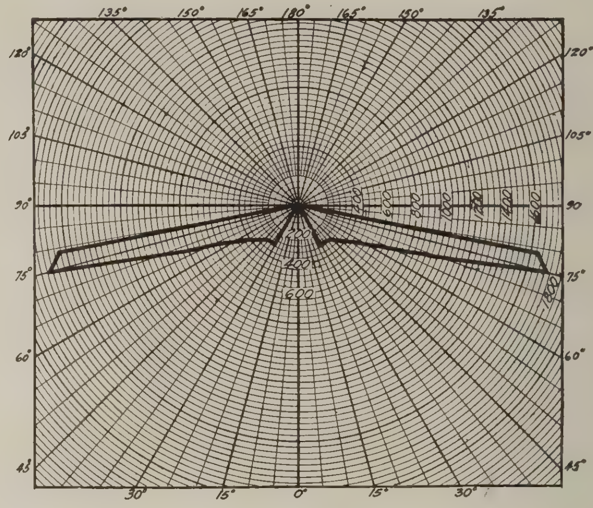


Fig. 6. Modified Ideal Curve of Fig. 5, Eliminating Angle of Light Zero to 30 Deg.

In order to know the location of a car at all times, it is necessary that the ends of a car be always lighted, irrespective of their position. This means that unit M will have to emit light as far as point "c," as also will unit "O."

Assuming that the units in a row are spaced 200 ft. apart, and with 45 ft. between rows, we have units M and Q in one row and unit O in another row 45 ft. away (figure 1). Under these conditions unit M will have to emit light up to point "B" or 79 deg.

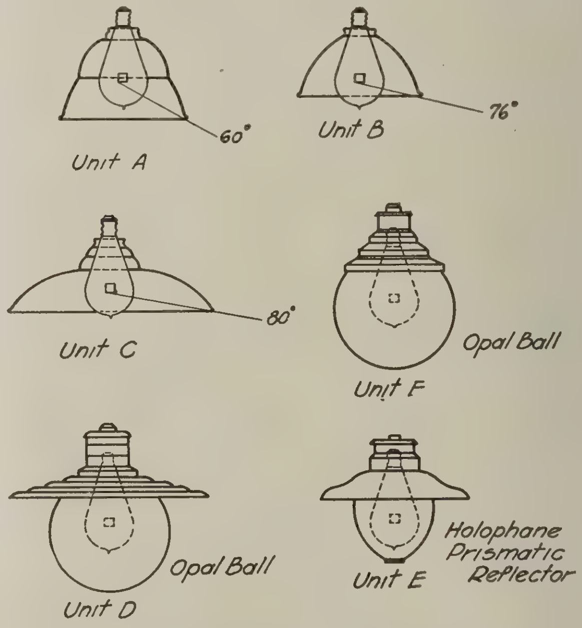


Fig. 7. Types of Units Now Used for Yard Lighting. Units A, B, and C are Porcelain Enameled Reflectors; D, E, and F, are Diffusing Glassware Units.

Table 1 shows other mounting heights and spacing of units.

TABLE NO. 1.
SPACING OF LIGHTING UNITS.

Light.	Mounting Height of Units.	Distance Between Units.	Distance Between Rows.
Good	35′	100′	45′
	55′	157′	70′
	75′	314′	100′
Fair	35′	200′	45′
	55′	314′	70′

Distribution of Light from Units to Obtain Perfect Lighting.

Fig. 3 shows the distribution required from units located at M, N and O to give a uniform vertical illumination on the ends of every car, irrespective of their position. It will be seen that when unit M only emits light up to 67 deg., unit N must give an impossible amount of light up to about 30 deg. This is on account of the light striking at such an acute angle on the ends of the cars directly under it.

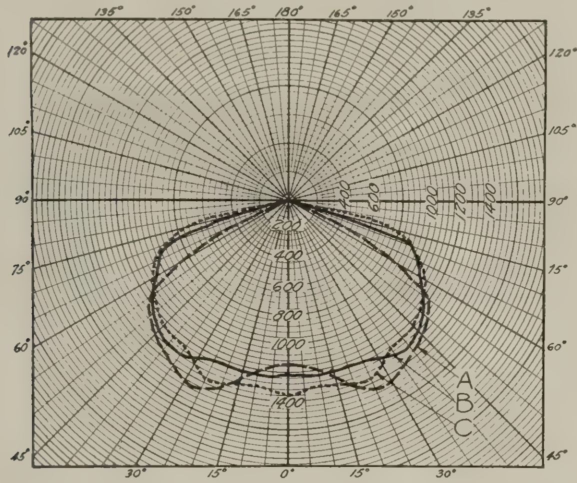


Fig. 8. Distribution Curves of Units A, B and C of Fig. 7.

To make the conditions more practical, it was assumed that unit M should light the ends of the cars out to the point "a" (30 deg. beyond unit N) instead of point "c." This makes the angle of light emission 70 deg. instead of 67 deg. Under these conditions, the ideal distribution for obtaining a uniform vertical illumination on the ends of the cars equal to ¼ foot candle is shown by figure 4. This curve will also take care of conditions as shown in figure 2, with units located at A and B.

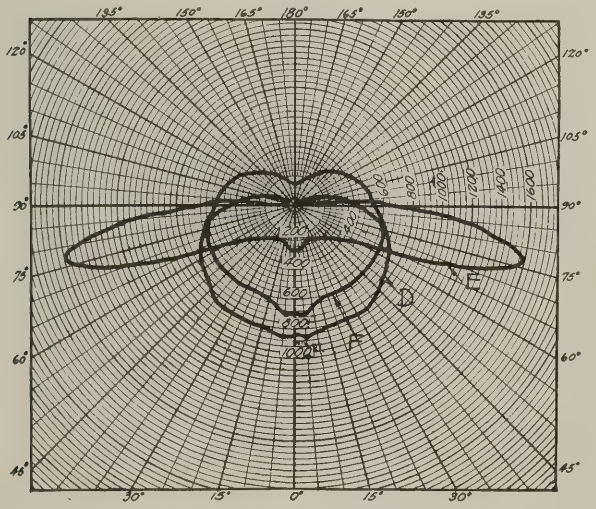


Fig. 9. Distribution of Units D, E and F, Fig. 7.

Fig. 6 shows the ideal distribution of light required to produce an even vertical illumination of ⅛ foot candle when units are mounted 35 ft. above the ground and the distance between units is 200 ft.

Fig. 4 applies equally well to units spaced 157 ft. apart with a mounting height of 55 ft. and a distance between rows of 70 ft.; or to units spaced 314 ft. apart with a mounting height of 75 ft. and a distance between rows of 100 ft., when the candle power values are multiplied by 2.47 and 4.59 respectively.

Fig. 6 applies equally well to units spaced 314 ft. apart with a mounting height of 55 ft. and a distance between rows of 70 ft.; or to units spaced 428 ft. apart with a mounting height of 75 ft. and distance between rows of 100 ft. when the candle power values are multiplied by 2.47 and 4.59 respectively.

Distribution of Light by Various Lighting Units.

Figure 8 shows the distribution of light obtained with units A, B and C, while figure 9 shows the distribution obtained from units D, E and F. These distributions are characteristic of practically every form of lighting unit at present available. It will be seen that the distributions from units A, B and C (figure 8) differ principally at the high angles (around 55 deg. to 75 deg). This is due to the angle of cut-off (shown in figure 3) more than to the shape of the reflector. It is impossible to obtain high maximum candle power in any given direction with a porcelain enameled reflector.

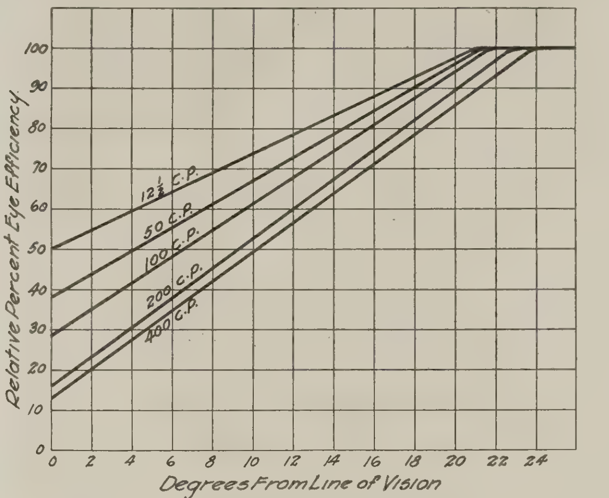


Fig. 10. Variation of Eye Efficiency with Angle of Light in the Eye.

The distributions obtained from units D and F (figure 9) are very similar and are characteristic of all opal enclosing units. No other form of distribution is possible with this type of unit. The distribution from unit E is unique in that it can only be obtained by the use of a specially designed enclosing refractor made of prismatic glass. This form of unit may be designed to give a high maximum candle power at any desired angle.

Glare.

Figure 10 shows the effect on the amount of glare produced by light entering the eye at different angles. The light emitted above the angle of 66 deg. from the nadir is that which produces glare. From this standpoint, unit A is the best unit shown by figure 7. Unit B is next and unit C the worst. Units D, E and F probably come some place between units B and C in the producing of glare.

Units Best Adapted to Yard Lighting.

Unit A is not practical to use with entire satisfaction for spacings covered by Fig. 4, as it cuts off at too small an angle. Unit B cuts off at just the right point, however, and is preferable to unit C both because it produces much less glare and because it is much cheaper in original cost.

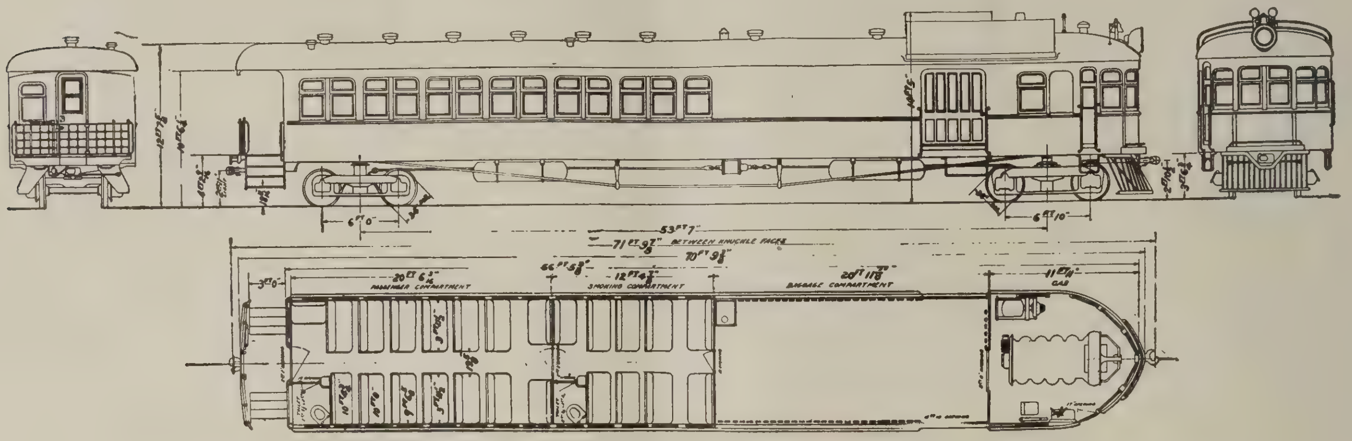
There is little question but that unit E should be used for spacings covered by Fig. 6.

Conclusions.

The data and calculations presented in this article are placed here for each one's individual study. No conclusions will be drawn except by each individual reader.

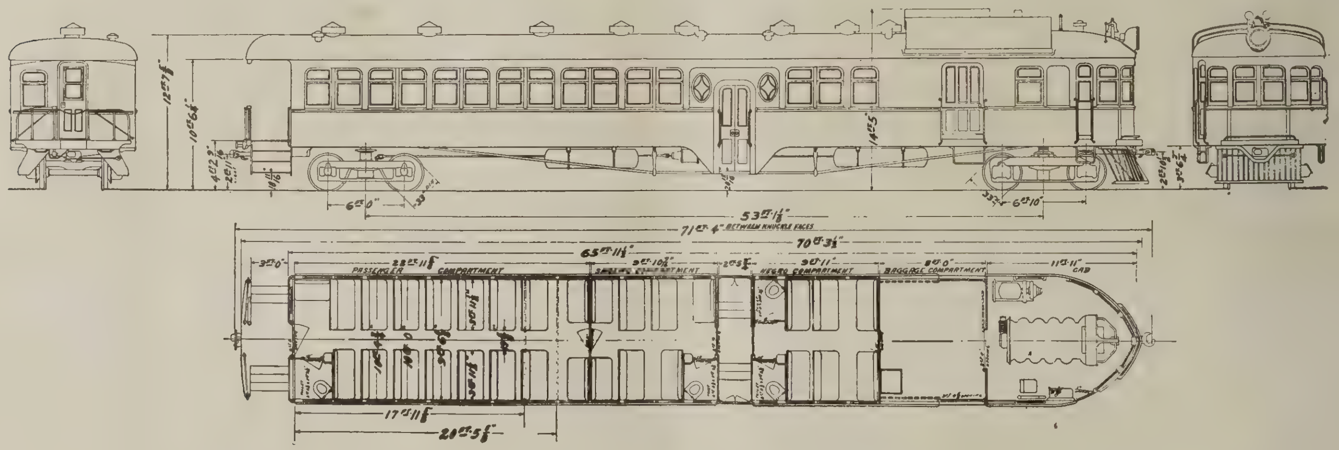
The Gas-Electric Car

The Spokane, Portland & Seattle Railway has contracted with the General Electric Company for a gas-electric motor car, which will be the first car of this type to be employed on this railway. It is the intention to place the car in operation between Portland and Rainier, Ore., on the Astoria-Columbia division of the road.


6FT 0"
6FT 10"
53FT 7"
71FT 9 7/8" BETWEEN KNUCKLE FACES
70FT 9 3/8"
66FT 5 3/8"
3FT 0"
20FT 6 3/16" PASSENGER COMPARTMENT
12FT 4 7/8" SMOKING COMPARTMENT
20FT 11 7/8" BAGGAGE COMPARTMENT
11FT 11" CAB

Plan of Car Which is to be Used on the Spokane, Portland & Seattle Railway.

Steam trains are now making two round trips each way per day between these two cities, 45.8 miles apart: making the run each way in about two hours.


6FT 0"
6FT 10"
53FT 1 1/8"
71FT 4" BETWEEN KNUCKLE FACES
70FT 3 1/2"
65FT 11 1/2"
3FT 0"
28FT 11 5/8" PASSENGER COMPARTMENT
9FT 10 3/8" SMOKING COMPARTMENT
2FT 5 3/8"
9FT 11" NEGRO COMPARTMENT
8FT 0" BAGGAGE COMPARTMENT
11FT 11" CAB
17FT 11 5/8"
20FT 5 5/8"
14FT 5"

Plan of the Cars Designed for Use on the Illinois Central R. R. Note the Side Entrances and Double Passenger Compartment.

The total distance for the four single trips per day is 183.2 miles. The gas-electric motor car will be required to haul regularly one 25-ton trailer seating 60 passengers. At times when traffic is heavy, it may be necessary to haul two trailers of this capacity on both round trips. The schedules of trains composed of the motor car and two trailers will be increased 10 minutes each run with stops of not more than 30 seconds. The maximum grade on this section of the railway is one-half of one per cent, extending over a distance of about 3 miles; but, in general, the road follows the Columbia river grade and is nearly level.

The Spokane, Portland & Seattle Railway runs from Spokane, Wash., through Portland, Ore., to Warrenton, Fort Stevens and Holladay on the coast. It connects with Seattle, Wash., over the Great Northern Railway and the Northern Pacific Railway. Other connecting lines are the Oregon Trunk Railway, Oregon Electric Railway and the United Railways. The road embraces a total of 556 miles, standard 4 ft. 8½ in. track gauge. The rolling stock equipment comprises 69 locomotives, 98 passenger cars and 740 freight and miscellaneous cars.

The gas-electric motor car for this railway is what is known as type RE-70-B-21. The details of construction conform in general to those of the standard cars manufactured by the General Electric Company. It will be noticed, however, that the baggage room in the car is about twice the usual length in order to transport the large quantity of express handled, particularly the heavy shipments during the fruit season.

The specific dimensions of the car are 70 ft. 11⅜ in. over bumpers by 10 ft. 6⅜ in. wide overall. It weighs approximately 51 tons and has a seating capacity for 68 passengers. The interior is partitioned into four compartments. The cab in front containing the power plant apparatus measures 11 ft. 11 in. long; next is the baggage room, 20 ft. 10⅞ in. long; then the smoking section, 12 ft. 6 in. long; and the passenger compartment 20 ft. 5⅞ in. long.

The car is equipped with two GE-205 600-1200 volt box frame oil-lubricated series commutating pole railway motors having a total of 200 hp. capacity. The motors are mounted with nose suspension directly on the axles of the forward truck. They are insulated for 1,200 volts so that they may be interchanged, if desired, with the motor equipments on the cars of the Oregon Electric Railway, which operates on the 1,200 volt system. The generating unit consists of an 8-cylinder, 4-cycle gas engine of the "V" type, direct-connected to a 600 volt, commutating pole electric generator, designed to meet the special conditions the service demands.

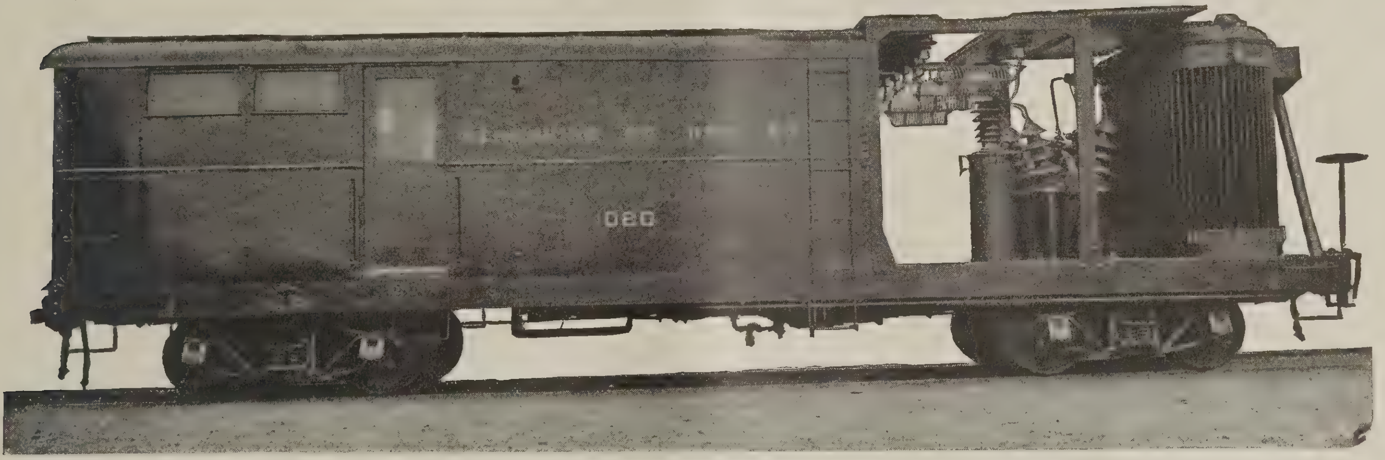
The body of the car is of the all-steel type of construction, except the seats and interior finish, which is of mahogany. A rear open platform entrance with body and platform railings is provided. The bearings and treads and flanges of the wheels conform to MCB standards. The trucks are of the heavy spring bolster type with elliptic bolster and coil equalizer springs.

The Illinois Central Railroad Company, Chicago, Ill., has also contracted for four gas-electric motor cars, which will be placed in commission for supplementary service on some of the connecting lines of the company. The railway company has not yet advised where all these cars will be placed in operation, but is canvassing the branch line service on its entire system to ascertain where they may be used to the best advantage. The initial installation will probably be distributed partly on southern and partly on northern branches of the road.

The details of construction are essentially as described above. These cars will seat 86 passengers and have 600 volt motors with a total of 200 h. p. capacity. Center vestibules with side entrances run between the passenger and smoking and between the smoking and colored passenger compartments. A rear platform is also provided.

Semi-Outdoor Portable Substation

The Berkshire Street Railway Company, Pittsfield, Mass., placed in service this last summer a new semi-outdoor type of portable substation for the purpose of supplementing the power supply on certain heavily loaded sections of the road during the increased summer excursion traffic. The substation was built by the General Electric Company and has a continuous capacity of 300 kw. at 600 volts, transforming from a 33,000-volt, 25-cycle, 3-phase line supply.



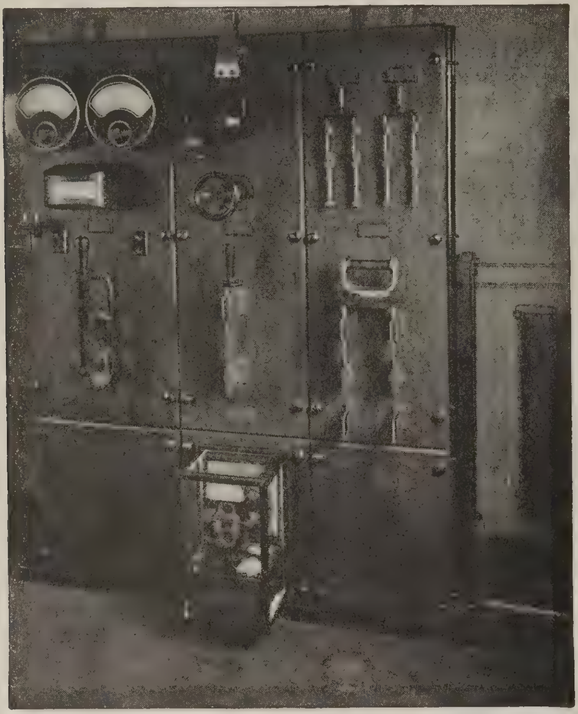
Side View of the Portable Substation Used on the Berkshire Street Ry.

By providing additional energy at any point where traffic may be temporarily abnormal, a portable substation of this type assures a continuity of power supply at a lower cost than would be incurred by the installation of spare units in many of the substations of an electric railway system, resulting in a considerable reduction in investment for equipment that under normal conditions might lie idle for long periods. Moreover, the portable substation can be transported quickly to a disabled section, where it will only be necessary to make connections to the high tension lines and direct current trolley or feeders for a temporary power supply. It is also very useful for furnishing power to extensions while under construction.

The portable substation for this railway represents one of the most modern designs. It consists of an enclosed operating compartment containing the synchronous converter, the three-panel switchboard and the three-unit electric heaters; an enclosed central room for the multi-gap lightning arrester equipment; and an open section for the main transformer, the current transformer, automatic oil switch, choke coils, disconnecting knife switches, etc. Owing to the low clearances of the various bridges on the lines, the car has been kept within the comparatively low height of 11 ft. 6 in. above the rails, including the running board.

The car is an all-steel structure, the underframe consisting of four 12-in. steel channels extending the entire length of the platform. The two center channels, which form a box girder, are provided with ⅜-in. top and bottom plates, so that reliance is not placed on the floor plates to give the required strength. All those channels are securely tied together at the ends by steel members and are cross-braced near each end, approximately under the center of the grouping of heavy apparatus, by a 12-in. steel channel. Cross-bracing of 6-in. steel angles at intervals is employed in the intervening central section of the framing.

At the converter end, two pairs of 6-in. steel channels extending across the car are firmly riveted on top the underframing, the space between each pair being filled with concrete. These members constitute the foundations for the machine, which is set on wooden blocks, provided with levelling plates and secured by anchor bolts in the usual manner. Ventilating openings are located in the floor of the car under the converter in order to insure a supply of cool air when the machine is in operation. The openings are fitted with removable sheet iron covers and permanent wire mesh screens.



Substation Switchboard.

The flooring consists of ¼-in. sheet steel; which extends across the plates on top the center girder and is laid with butt joints and flush rivets. At the outdoor end of the car, two 6-in. channels are run crosswise and form part of the floor framing for supporting and anchoring the transformer. Special attention has been paid to the method of framing these channels into the center box girder and the side channels, the framing being equivalent in strength to the sizes of bolts holding down the transformer.

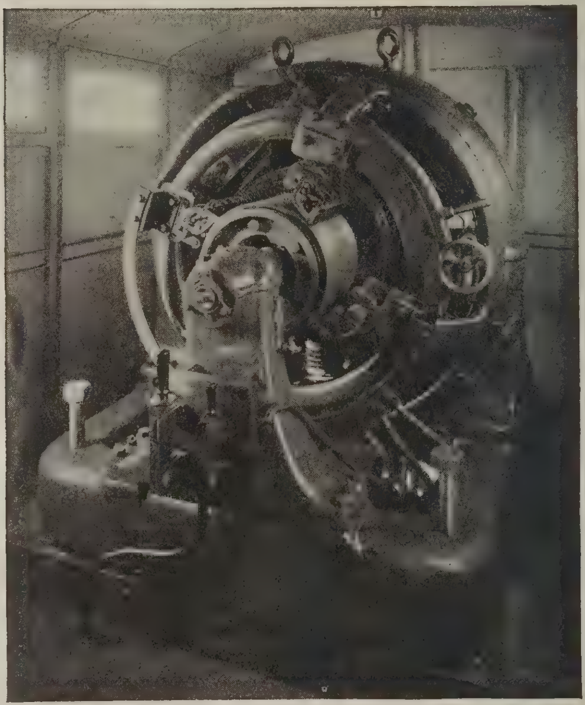
In the open end of the car, four vertical channels with the four upper channels forming the cross framing constitute the support for the disconnecting switches and choke coils.

A snow shield formed of sheet steel of No. 12 B. W. G. and framed with angles extends from the center on top of the support over to a wooden block base on the transformer top. This protects the high tension bushings to the transformer, which are brought out in a horizontal position because of lack of overhead clearance on the road, and also those to the oil switch units and the current transformer. A short cover likewise extends over the incoming line leads and those to the lightning arrester compartment at the other end of the supporting frame. The incoming insulators each side of the choke coils are suspended from cross steel angles tied into the framing.

The current transformer and the oil switch units are fastened down with the usual wooden cleats and angle lugs riveted to the floor plates. In the lightning arrester compartment, a steel angle is placed longitudinally near the top of the compartment and riveted to the partitions to anchor and support the arrester units.

The side and roof framing of the closed sections and partitions of the car consists of steel channels and angles properly braced and riveted together. The sides and roof are enclosed with sheet steel, No. 12 B. W. G. for the lower half of the siding and No. 14 B. W. G. for the upper half and the roofing. A horizontal channel is used where the upper and lower sections of the side sheathing are riveted together.

The operating compartment end of the car is bolted to the sides and roof so that it may be entirely removed for the installation or removal of the apparatus. The section of the roof over the converter is also bolted down so that it may be readily removed for installing or dismantling the apparatus when a crane is available. A galvanized sheet metal ceiling is built on the interior so as to form air pockets between it and the roof sheathing to prevent any direct radiation of heat when the car is standing in the sun and also to drain any condensation or possible leakage to one side of the car away from the apparatus.



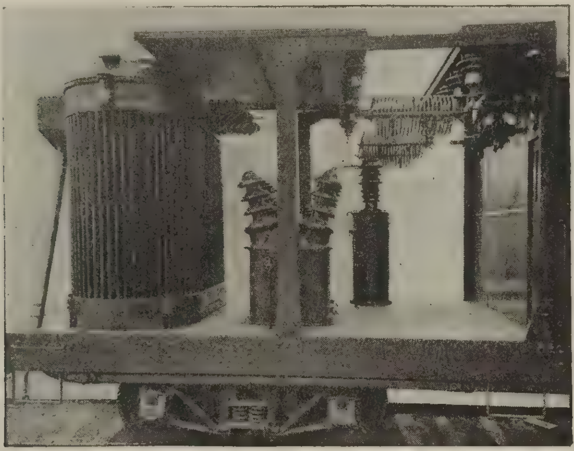
Three Phase Twenty-five Cycle, 600-Volt Commutating Pole, Synchronous Converter.

The car is provided with four doors, one on each side entering from the outside into the operating or synchronous converter compartment, one in the side of the partition connecting the operating and lightning arrester compartments, and one entering the latter compartment at the other end from the outdoor portion of the substation. The doors are built with metal protected wood frames and have top panels of wire glass. In addition to locks, they are provided with a chain with hook and eye to prevent ingress when the door is left partially open. Grab rails and steps are furnished at the side doors, as well as steps and grab rails at each end of the car, ladders at the sides leading to the roof and a wooden running roof board in accordance with Safety Appliance standards.

Four top wire glass windows are located two on each side in the operating compartment. They are pivoted at the center and are provided with catches to hold them in a fully open position for ventilation or in a fully closed position.

The trucks are of the diamond frame arch bar type, equipped with 33-in. wheels mounted on MCB standard steel axles and fitted with cast iron journal boxes. They are built to take a curve of 40 ft. radius or approximately a 150 deg. curve.

The car is supplied with standard brake rigging and shoes acting on all wheels of both trucks and operated from automatic air brake equipment with hose connections, as the car must conform to MCB standards throughout, to be shipped over steam railroad lines to its destination. A handwheel and brake shaft is also provided at the outdoor end for operating the brakes on one truck only. Standard draft gears and couplers with hand levers at the side of the car are supplied.



Transformer Showing Snow Shield for the Protection of the High Tension Bushings.

The electrical equipment includes a 3-phase, 25-cycle, 600-volt, commutating pole, sychronous converter operating at 750 r.p.m. The transformer connections are arranged for alternating current starting from 50%, secondary taps, with series resistance to cut down the initial rush of current. The machine has a normal rating of 300 kw. continuously, 450 kw. for two hours and a momentary overload capacity of 900 kw. This high overload capacity is considered a very important feature for interurban railway substations.

The temperature guarantees and insulation tests follow the recommendation of the A. I. E. E.; as follows: Full load temperature rise 24 hr., 35 deg. C.; 150% load, temperature rise 2 hr., 55 deg. C.; high potential test, armature, 2,000 volts ;high potential test, shunt fields, 5,000 volts. The series field is designed to give practically flat compounding at all loads without shunt field adjustment.

The machine is equipped with a speed limiting device, mechanical end play device, field breakup switch, equalizer switch, 1,000 ampere negative line switch, field rheostat, back-of-board type starting resistance, and levelling device. The usual brush-raising device is also applied for use in connection with a. c. starting. The equalizer and negative line switches are mounted on the outer pillow block. An opening is provided in the floor for connecting the equalizer to a stationary substation if parallel operation is desired.

The transformer is an oil-insulated, self-cooled, outdoor type, rated 330 kv-a., 3-phase, 25 cycles. Voltage taps are arranged on the primary, or high tension side for unusual flexibility, operating at either 33,000, 13,000 or 11,000 volts Y by using either series or multiple connections of the primary coils. The secondary, or low tension winding, is designed for 385 volts and is provided with the 50% starting taps previously mentioned. Series resistance is also used in starting. In order to make the secondary leads weatherproof at the point of entrance, they are enclosed in a small sheet iron box, from which the connections are carried to the switch panels through conduit. The transformer is designed with high inherent reactance to give practically flat compounding on the d. c. side of the converter.

The transformer is rated in accordance with A. I. E. E. recommendations, the allowable temperature rise after 24 hr. operation at full load being 35 deg. C. After two hours' operation at 150% load, the temperture rise will not exceed 55 deg. C. Three times normal load on the converter, or 900 kw., can be carried momentarily. The high potential insulation test required was: High tension winding, 66,000 volts; low tension winding, 2,000 volts.

The current transformer for the automatic tripping device is a 15-30 ampere special outdoor type. It is installed in the outdoor section directly back of one of the oil switch units and connected to the high tension circuit.

The automatic oil switch is a 300 ampere, 45,000 volt, triple pole, single throw, outdoor type. The series transformers and tripping device are self-contained. The operating mechanism is entirely enclosed and the units are fitted with outdoor bushings, thus being adequately protected from exposure to the weather. The switch is provided with bell alarm to notify the attendant when the switch opens. This oil switch trip is instantaneous in action, so as to afford complete protection to the machines and feeders under short circuit conditions.

The a. c. lightning arrester is of the standard multigap type, consisting of a series of spark gaps shunted by graded resistances, but without series resistance. It may be connected for protection of either the 33,00 volt circuits or the 13,000 and 11,000 volt high tension supply.

The three 33,000 volt, 300 ampere disconnecting switches are the single pole, single throw, outdoor type. They are installed immediately under the high tension entrance opening and are connected in the main line circuit, so that they cut out all the apparatus in the station, including the lightning arrester. If it is necessary to make any adjustments on the lightning arrester, the line circuit will be opened and the lightning arrester circuit disconnected by hand. An 8-ft. switch hook is furnished for manual operation of the switches.

The three 200 amp. choke coils are the cylindrical, outdoor, suspension type. They are supported in a horizontal position by the disconnecting switches at one end and by insulators at the other. The d. c. lightning arrester for the 600 volt d. c. feeder circuit is the aluminum cell type and is mounted inside the car back of the d. c. switchboard panel.

The switchboard is composed of three panels: A transformer panel, d. c. feeder panel and a. c. starting panel. The panels are of natural black slate and are mounted on pipe framework. The transformer panel is 48 in. by 20 in., and the feeder and starting panels are each 48 in. by 16 in. All three panels have 20-in. sub-bases. The instruments are all a dull black finish to match the panels.

The equipment installed on the transformer panel consists of one 1,500 ampere ammeter with shunt; 750 volt voltmeter; 385 volt 5 ampere wattless component indicator with 300-0-300 kw. scale; operating lever for the automatic oil switch; two 2-point potential receptacles, and one 2-point plug and holder.

The d. c. feeder panel is equipped with one single pole, 600 volt, 1,000 ampere, carbon break circuit breaker, hand operated, with low voltage release and bell alarm switch; handwheel with mounting and field rheostat; single pole, single throw, 600 volt, 1,000 ampere lever line switch and a 600 volt, 1,500 ampere, two-wire recording watthour meter installed on the sub-base.

On the synchronous converter starting panel are installed a double pole, double throw, 800 ampere synchronous converter starting switch and two double pole, single throw, 250 volt, 100 ampere lever switches with enclosed fuses on the front of the panel. These last mentioned switches furnish current to the lighting and heating circuits. Card holders are mounted over the switches on all panels.

Current for lighting the two interior compartments and the outdoor section and for heating the operating compartment is taken from the partial voltage taps on the transformer secondaries. The heaters are fastened to the partition and side of the car at one end of the switchboard. They consist of three units normally rated at 900 watts each. Each unit has two coils, making a total of six coils connected in parallel with separate switches on the heater to secure a gradation of heat. All cable leads and wiring are run in iron conduit securely fastened to the car framing. Monitor entrance bushings are provided at the ends of the conduit.

The specific dimensions and important data applying to this portable substation are the following:

Length overall	38 ft.
Width over sides of car	8 ft. 4 in.
Maximum width (over side channels)	8 ft. 6 in.
Height overall (including running board)	11 ft. 6 in.
Height of floor above rails	3 ft. 8½ in.
Total length of enclosed cab	23 ft. 6 in.
Length of converter or operating room	14 ft. 6 in.
Length of lightning arrester compartment	9 ft.
Length of outdoor section	14 ft. 6 in.
Truck base	25 ft.
Wheel base	5 ft. 2 in.
Wheels	33 in.
Track gauge, standard	4 ft. 8½ in.
Total weight	80,000 lbs.

Electric Lighting

A Factor in Civilization

A Joint Meeting of the A. I. E. E., W. S. E. E. and I. E. S. was held in the rooms of the Western Society on November 14th, 1914. Mr. Durgen, who represented the three societies, introduced the speaker of the evening, Mr. S. E. Doane, who gave his paper, "Electric Lighting—A Factor in Civilization."

Mr. Doane illustrated his discussion by means of lantern slides and experimental demonstrations, which made his points most effective. In the first part of his paper, in discussing what constitutes a benefit to civilization, he said anything that permanently advances civilization benefits the community either as a whole or individually. For example, our water works systems, steam railroads, and mail service.

The last century was an age of advancement in all things electrical; the street railway now reaches the humblest, the telegraph is at the command of nearly every member of society, but this is not yet true regarding the telephone and electric light. These are problems of the present.

It was through the efforts of Edison that the modern electric light has reached its present high stage of development. So the electric light now has the initial advantages of convenience, safety, and the cost is being continually reduced.

The incandescent lamp is but one of the two vital factors necessary that electric lighting may be a success, the other being electric service. This has been so improved that in the last twenty years the cost of producing electric light has been reduced to 1/10 of its former value. This is partially accounted for by the fact that of the present lamps in service 70% are of the tungsten filament class. Continuous improvements have been made in the quality and efficiency of lamps and new systems of distribution have been introduced. The great problem is to subdivide distribution to such an extent that it will be profitable to extend lighting service to the smallest customers. Electricity should be the universal illuminant for all classes.

Mr. Doane pointed out that as an electrical instrument the incandescent lamp has been of small interest to electrical engineers since the problem involved in its manufacture are nearly all outside of electrical engineering. Their interest is principally connected with reducing the cost to the ultimate consumer. Even small lamps are 25% more efficient than they were formerly and are rugged, as may be seen from their extended use in street car and railway service.

Continuing, he shows that the 25, 40 and 60-watt lamps are now operating at 1.05, 1.03 and 1.00 w.p.c. respectively, compared with 1.23 w.c.p. five years ago. For the 40 and 60-watt and 1.31 w.p.c. for the 25-watt and are giving the same useful life as before. At the same time the price for the 40-watt lamp has been reduced from $1.10 in 1908 to 30c in 1914, and in the last five years the cost of light has been reduced 30% to the ultimate consumer.

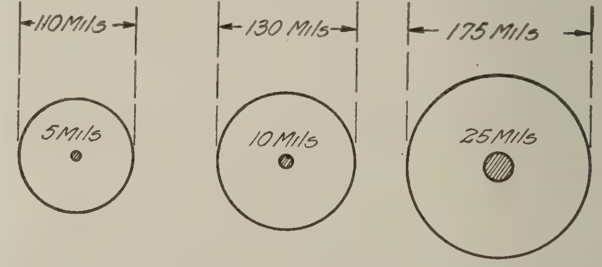


Fig. 1. The Outer Circles in This Figure Represent the Diameters of the Stationary Gas Surrounding Filament, as Assumed by Dr. Langmuir.

If we take an ordinary vacuum lamp operating under normal conditions with its filament at about 2,400 degrees centigrade absolute and assume that we could fill the bulb with an inert gas, such as nitrogen, to approximately atmospheric pressure, we would find that in order to maintain the filament temperature at its previous value, we would have to put a great deal more power into the filament. This additional power would be required to supply the heat lost through the gas. The increase in the amount of energy necessary to maintain a given temperature in an inert gas depends upon the character of the gas, its pressure, etc., and upon the size and form of the filament. The loss is relatively much greater in the case of a small filament than in the case of a filament of larger diameter or than in the case of a filament coiled in a helix, which gives the same general effect as a straight filament of very large size. If we assume that the temperature is maintained at the same value, the candlepower emitted by the lamp would be unchanged as it is a function simply of filament temperature. The introduction of the inert gas results primarily in requiring an increase in the amount of electric power put into the filament per candle-power produced, when the filament is operated at a given temperature but it also has an important effect on the rate of lamp depreciation. When heated above a certain temperature the filament of an incandescent lamp will evaporate at a rate which increases very rapidly as the temperature is raised. When a filament is heated in vacuum the particles evaporating from its surface travel freely to the bulb where they form a film of increasing thickness and capacity. The diameter of the filament is reduced as material is thus vaporized and this material, condensing upon the bulb, absorbs a portion of the light omitted by the filament. The life of a lamp depends primarily on the rate at which this evaporation proceeds.

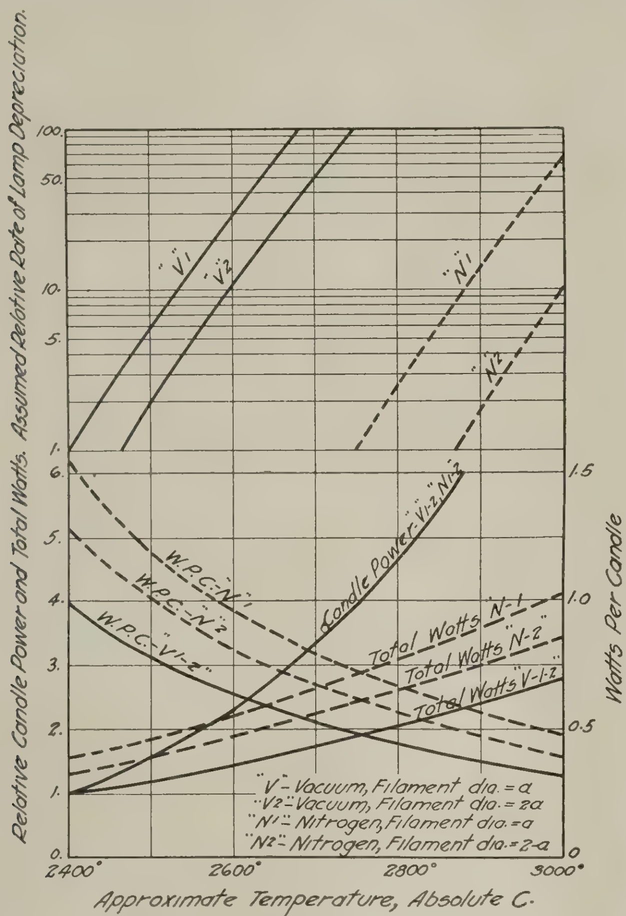


Fig. 2. Theoretical Curves Showing Variation of Candlepower, Watts and Depreciation with the Temperature.

By filling the bulb with an inert gas most of the particles vaporized from the surface of the filament are reflected back to the filament surface by collision with the gas molecules very near the surface so that relatively few of the particles evaporated attain their permanent liberty. Under such conditions the net rate of loss of material from the filament is very small compared with what it would have been if the filament were maintained at the same temperature in a vacuum. If the heat losses of the filament have not been too great this increase in temperature, made possible through the decreased rate of lamp depreciation, may more than compensate for the decrease in efficiency, so that we ultimately find that we have a lamp which when operating at a temperature giving the same rate of filament evaporation as the vacuum lamp actually consumes less w.p.c. The loss of heat from a filament in an inert atmosphere increases more slowly than the size of the filament.

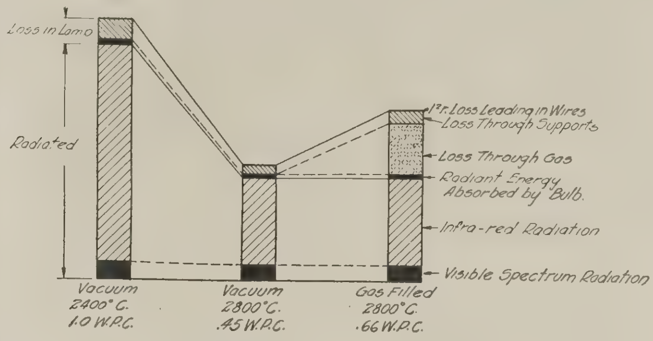


Fig. 3. Analysis of Power Consumed—Tungsten Filament Lamps on Basis of Luminous Equal Output.

Figure one illustrates the result of research work by Dr. Irving Langmuir, which serves to explain the reason for the relatively greater heat loss from small filaments when operated in an inert gas than from heavy ones. He assumes the existence of a stationary film of gas immediately surrounding the filament, which carries heat from the filament by conduction only. The diameter of this conducting film of gas increases, according to his experimental work, at a lower rate than the filament diameter. A filament coiled in helical form has the advantage of a relatively smaller heat loss per unit of length—the amount of reduction depending upon the size of filament, diameter of coil and pitch, and, of course, on the character of gas, pressure and other details of construction.

Some of the more important characteristics of vacuum and gas filled lamps, operating as different filament temperatures are illustrated in Fig. 2, these relative values having been worked out on the basis of data published by Dr. Langmuir, taken in combination with other experimental work, and are intended only to illustrate the general effect of several factors entering into the discussion. The relative rates of lamp depreciation have been assumed to follow the relation between rate of evaporation of tungsten and temperature as determined by Dr. Langmuir but take into consideration the effect of filament diameter on the actual life of the lamps, for at the same temperature of operation a larger filament will last longer than a small one.

Mr. Doane showed very nicely the effect of an inert gas within the bulb by means of several experimental lamps which he exhibited. Two pairs of bulbs were fitted with coiled filament, the filament of one being comparatively large and the other small, one lamp in each pair was of the vacuum type and the other was filled with nitrogen. In each case these two lamps were arranged in parallel. When the current was turned on in the case of the heavy filament lamps the vacuum lamp glowed brightly, while the lamp filled with nitrogen was not quite heated to incandescence. The difference was more marked with the small filament lamps, the vacuum type lamp again glowed brilliantly, but the nitrogen filled lamp only was heated to a dull red. This demonstrated that the smaller the filament the greater is the proportion of heat carried away by the gas. The effect of the gas temperature was well shown in a lamp with an elongated bulb. When this lamp was held right side up the top of the filament was incandescent, while the bottom was only red. Upon inverting the lamp the brilliant portion of the filament moved visibly to the top end of the bulb for the natural circulation of the gas within the bulb allowed the upper portion of the filament to reach the proper temperature.

Regarding the factors which determine the pitch and diameter of the helical coils used in the new lamps, Mr. Doane says there are, of course, practical limits to the size in which filaments can be coiled, for it is essential that the coils should not come into contact one with the other during the life of the lamp. This limits the size of the mandrel upon which the filament can be wound and also affects the pitch of the winding or the distance between turns. The perfection of the gas filled lamps required a careful adjustment between these several factors and naturally much experimental work has been done with reference to the construction of coils which will permit a maximum efficiency to be obtained without increasing too greatly the possibility of mechanical difficulties with coils sagging and touching.

The power put into an incandescent lamp is ultimately dissipated as heat. Even that portion of it transformed into radiation in the visible spectrum ultimately appearing in this form. Fig. 3 indicated the various ways in which this power supplied to the lamps is used up. Here we have a power consumption of one watt per candle for the filament in vacuum at 2,400 deg. cent., .45 w.p.c., with filament in vacuum at 2,800 deg. and .66 of a watt per candle for the filament at 2,200 deg. in the gas filled lamp assumed for comparison. Although the filament operating in vacuum at the same temperature as in the gas filled lamp is much more efficient, it would have materially shorter life. So the heat losses in the case of the gas filled lamp are relatively greater than in the vacuum lamp. The use of the gas filled lamp is still justified, for with a normal life, it has a higher overall efficiency than the vacuum lamp.

Provision must be made to radiate the heat that is carried by the gas from the filament of the lamp. Thus far the multiple burning lamps and the high power series lamps have been designed to be operated in a vertical position, base uppermost, the bulb surface being particularly arranged to care for the heat carried to it by the gas. By using a helical coil a great many advantages are obtained. The concentrated light source is of a distinct advantage in the art of lamp manufacture for use with projection lantern or stereopticon work. The intrinsic brilliancy can be still further increased by operation at a higher filament temperature, which will, however, cut down the effective life of the lamp; but the more intense white light and increased efficiency often makes this advisable. The white light of this lamp is a distinct advantage, as a whiter light is generally much to be preferred in commercial lighting. By using the large sizes of the gas filled lamps it is now possible to obtain illumination of a true north sky quality at an expenditure of about 5 w.p.c. If we wish to approximate a light quality equivalent to that obtained from noon sunlight, a much higher efficiency can be obtained—something about 1¼ w.p.c., practically the same efficiency of light production which was common to tungsten filament lamps in general but a few years ago. These lamps also find extended application in photographic work. The high efficiency and high actinic value of the light has given most excellent results. A special blue glass has been designed for use with lamps intended for such service.

After the systems of lighting had been developed it became necessary to devise some system by which a customer could pay for his light. The earliest systems of charging were based on the candle-power, but at present it is more common to pay for electricity used and electric service; thus the pendulum has swung from one extreme to the other, neither one entirely covering the ground, as there are other features which must be recognized. This, however, is one of the things which must be developed, as in the case of water supply, sewage disposal and street car service.

As an electrical instrument, the incandescent lamp is a most inefficient means of transforming electricity into useful energy and even though this efficiency is three times its first value, it still is only about 5%. The problem is no longer up to the engineers of the central station and of the manufacturing companies, it is up to the engineers of distribution, who must economically wire the rooms they would serve and the accountants must devise a means for economical transferring adequate compensation from the service of the served to the server.

Mr. Doane concludes:

I was profoundly impressed a year or two ago when pursuing some investigations in Europe, by the oft-repeated statement of managers of large properties that they introduced certain policies because of political necessities. They mentioned these political necessities in the broad sense of the obligations and demands of the community and not in the sense that they were catering to demigogy or expediency. They have reached the conclusion that commercial safety to themselves and others lay broadly in the direction of the extension of electrical service to every political unit. The electrical industry in general will sooner or later awaken to this fact and when it does, and only then, will electrical service assume its proper importance as a factor in civilization.

B. & O. R. R. Abandon Headend Lighting of Trains

For several years past the B. & O. Railroad have lighted four of their through trains between Chicago and New York with the headend system, having a 20 k.w. Curtis turbo-generator set mounted in the baggage car, which furnished light for the entire train. A lamp regulator of the carbon pile type was installed on each car and a voltage sufficient to charge the batteries was maintained on the train lines. On account of the frequent division points at which the train was broken up and cars inserted or withdrawn, storage batteries were required on nearly all the cars of the train.

It has now been finally decided to abandon the headend system for train lighting because of the inflexibility and high operating costs under the conditions met with on that road. As soon as it is possible to make the change, 30-volt axle equipments will be installed on the cars of these trains.

Shop Motor Section

The Two Speed Motor

One of the greatest objections to induction motors has always been the lack of economical speed control. Of quite recent date a two speed motor has been introduced into the electrical field, to be applied to such shop machinery as may require different speeds. The speeds above, below and intermediate to both speeds of the motor, which are required on such machines as wheel lathes, shapers, etc., are obtained by shifting the gearing of the machine itself.

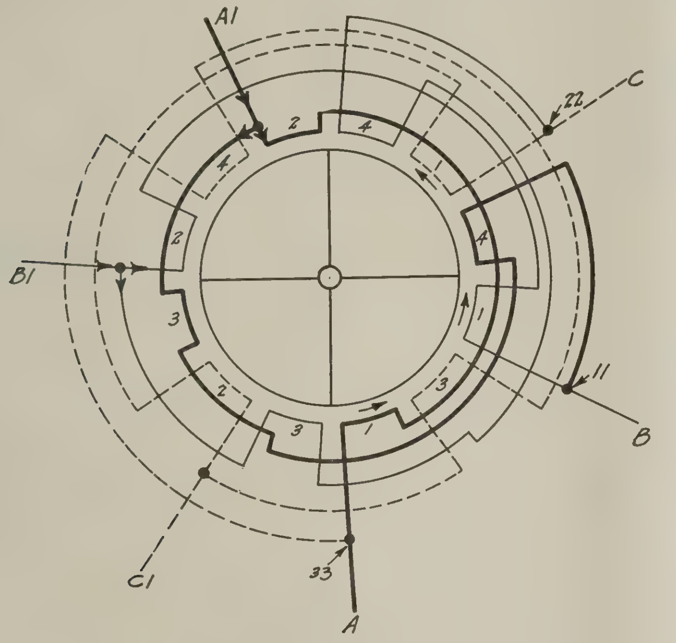


Fig. 1. Winding Diagram of Two Speed Motor.

In appearance and mechanical design this motor resembles any other squirrel cage motor; the rotor is identical. A very marked difference is found in the connections of the winding of the stator elements. By merely throwing a switch the number of poles in the stator is doubled.

It will be recalled that the synchronous speed of an induction motor, in revolutions per second, is equal to the frequency or the cycles per second divided by the number of pairs of poles, so that by doubling the number of poles the speed is decreased one-half. For motors having two speeds, for example, 900 and 1,800 r. p. m., the number of poles in the stator corresponding to these two speeds is 8 and 4 respectively, with the frequency of the supply being 60 cycles per second.

Fig. 1 shows the end connections that are used with a 900 and 1,800 r. p. m., 60 cycle, three phase motor. The quartered circle within the center part of the diagram represents the four poles set up in the stator winding. The three phases are represented by heavy, dotted and light lines, each quarter or pole being composed of three phases, each phase in numbers 1-2-3-4, etc.

No special auto starter is required in the connection of the motor but a special four pole, double throw switch, shown in part (c), Fig. 2, having thirteen points, is needed and placed between the motor and the auto starter.

It will be noted that when the switch is closed in the upper position, one blade short circuits the three leads connected to the bottom of it, these three jumpers are put on at the time of installation.

When the machine is set for low speed operation with the switch thrown to the down position and the leads from the motor marked (A, B, C), Fig. 1, are connected to the respective leads from the switch marked in a similar manner and to the line through the auto starter while the leads from the motor marked (A1-B1-C1) would be open.

From Fig. 1 it is seen that at any given instant the direction of flow of the current in each phase winding of each pole is the same. For example, by tracing (A) phase through, beginning at (A), each group of coils marked 1-2-3-4 are placed to form positive or north poles, the negative or south poles being of a consequent formation; therefore, when the switch is thrown for low speed, or the higher number of poles position, four positive or north poles and four negative, known as consequent poles, are produced.

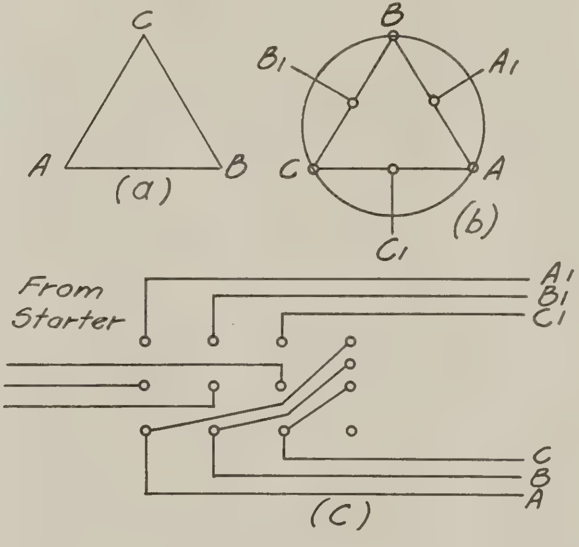


Fig. 2. Method of Wiring Four Pole Switch.

The end of (A) phase winding ends at the beginning of (B) phase and is marked (11); the end of (B) phase winding ends at the beginning of (C) phase and is marked (22); the end of (C) phase winding ends at the beginning of (A) phase and is marked (33), thus forming a delta connection as shown in part (a), Fig. 2.

When the four pole switch is thrown to the up or the high speed position, the leads (A1-B1-C1) from the motor shown, Fig. 1, are connected through similar marked leads of the switch, hence through the auto starter to the line and the motor leads (A, B, C) are short circuited.

Referring to the diagram again and tracing the path of current through any phase, for example, (A) phase, we begin at (A-1) and find that the current goes both ways, thus forming two negative poles (2-1) and two positive poles (3-4). The other phases (B and C) may be traced in the same manner, thus when the switch is thrown to the position for the higher speed or the lower number of poles, the windings are connected so that alternate north and south poles are produced.

With this connection, the switch being up, the leads (A-B-C) are short circuited, as shown in part (b), Fig. 2, the circle representing the short circuit. The circuits are split and fed both ways from the points (A1-B1-C1), forming a parallel star connected winding.

Upon first thought it would seen to be the same to connect (A-B-C) in the place of (A1-B1-C1) at the switch; this, as has been shown, is an error, however. Although the motor will operate with either connection, the magnetic flux will not be evenly distributed when the motor is running at the high speed with the reversed connection. By following out the through connections in Fig. 2 (B), and in Fig. 1, this may be verified.

The Railroad Electricians' Club

Meetings the 3rd Monday of Every Month, 8 P. M.—18th Floor Transportation Bldg., Harrison and Dearborn Sts., Chicago—Everybody Welcome—No Dues

Lead Storage Battery Questions

Taper Charge.

Prob. 56. What is meant by giving a battery a taper charge?

Ans. 56. A taper charge is where the current starts out at a high value at the beginning of charge and gradually diminishes to a low value near the end of charge. This kind of a charge is usually given the battery by connecting it directly to a circuit of constant potential. As the battery charges, its counter electro motive force rises gradually and this opposes the flow of current, causing it to be reduced to a low value at the end of charge.

Taper Charge on Axle Equipments.

Prob. 57. Can this be produced on an axle equipment?

Ans. 57. A modified taper charge is produced by nearly all of the axle equipments on the American markets today, although none of these equipments operate on a strictly constant potential basis, for the current rate at the start of charge for a very low battery might be excessively high and overload the generator.

The E. S. B. equipment operates on a strictly constant potential basis, except that the current is limited from going above the capacity of the generator. Within the capacity of the generator, however, the charging current tapers down automatically with the rise in counter electro motive force on charge.

With the Gould and Safety equipments the battery charges at a constant current rate until the charging voltage rises to approximately 40 volts, whereupon the voltage control of the system becomes effective and prevents further rise in charging voltage above that point. As the battery charge proceeds further, the counter electro motive force of the battery rises higher and, opposing the impressed voltage, will cause the charging current to gradually taper off to a low value.

In the Consolidated type "L" system, with ampere hour meter control, as described in our August, 1914, lesson, No. 31, the battery is charged either on principle of battery current control, in which the current to the battery is maintained constant regardless of lamp load, or on the principle of constant generator current control, in which the current to the battery varies inversely with the lamp load. An ampere hour meter records the total charge and when this equals the previous discharge plus 20%, and provided battery voltage is above a certain point, the charge is terminated. The battery then simply floats on the line, with neither appreciable charge nor discharge, current flowing until the next stop.

In the latest U. S. L. system with ampere hour meter control the battery charging current is maintained constant until the ampere hour meter indicates a full state of charge. This meter will then close a contact, which will indirectly cause the voltage modifying coil to operate and thereafter the generator will be controlled at approximately 35 volts, the battery simply floating on the line.

When is a Battery Charged?

Prob. 58. What are the different methods by which you can tell when a storage battery has been brought up to full state of charge?

Ans. 58. There are three methods by which the state of charge of a battery may be indicated: (1) The voltage on charge or discharge; (2) specific gravity of the electrolyte; (3) the indication of the resistor type ampere hour meter connected permanently in the battery circuit.

Prob. 59. Are all of these methods reliable?

Ans. 59. (1) The voltage reading on charge or discharge is only a rough indication of the state of charge of the battery. It depends upon a number of variable factors, such as the charging current rate, temperature, strength of electrolyte, conditions of plates, etc. The open circuit voltage of a battery means nothing, always let a battery either charge or discharge 5 or 10 minutes before taking a reading, etc. Numerous devices have been designed to automatically cut off the charge of a battery when its voltage rises to a certain value, but because of the uncertainty of the voltage indication, these devices have never been successful.

(2) The specific gravity readings may be taken as a very accurate indication of the state of battery charge, provided, however, that the level of the electrolyte in the pilot cell is carefully maintained at a certain height. When this varies an inch or more, as it does in car lighting service, the specific gravity readings may give a misleading idea of the condition of charge. Temperature of the battery must also be noted and proper correction in gravity made.

(3) The resistor type ampere hour meter permanently installed in the battery circuit, which records

all previous discharge and runs 20% slower on charge than on discharge, automatically providing a charge in excess of the discharge to make up for battery losses, should give a fairly reliable indication of the condition of the charge. It should be pointed out, however, that the actual ampere hour efficiency of a battery depends altogether upon the service which it receives. In other words, a battery which is frequently discharged and charged intermittently will show a fairly high battery efficiency, even as high as 99% in extreme cases. On the other hand, a battery which receives very little discharge or is allowed to stand idle very long, may show an extremely low battery efficiency and an ampere hour meter set to provide only 20% excess charge may give an entirely wrong indication of the state of charge of the battery.

The experience of operating a large number of axle car lighting systems on the ampere hour meter principle will undoubtedly show what ampere hour efficiency should be assumed and the meter can then be set to operate at that value. Even though the meter be set to provide twice as much overcharge as actually required, that is, if it were set for 30% overcharge where actually only 15% were required, this error would probably cause only a slight overcharge in ampere hours, for this excess overcharge would be simply 15% of the total ampere hour discharge.

Why Didn't the Stop Charge Relay Make Good?

Prob. 61. What was the reason that the voltage coil, "stop charge relays" have proved so unsatisfactory in car lighting service?

Ans. 61. As mentioned in Problem 59, voltage relays can never be depended upon for automatically terminating the charge given a storage battery. The voltage of a battery at the end of charge depends upon: (1) The current rate (the higher the current flowing into the battery, the higher charging voltage will be required); (2) temperature, at low temperature, around zero or below, a 30-volt battery may require as high as 45 volts at the switchboard to bring it to full state of charge with normal charging current flowing; (3) condition of plates, an old battery will charge at a somewhat lower voltage than a new battery will as a general thing, also the condition of the plates as regards sulphation may greatly change the charging voltage; (4) a battery with electrolyte of abnormally high gravity will charge at a lower voltage and one with abnormally low gravity at a higher voltage than a normal battery will.

In other words, if an axle equipment with a voltage control relay for stopping charge at the proper time be ever so carefully adjusted in the factory, and even work with entire satisfaction on the road for some time, and even though the adjustment of the relay may be maintained exactly constant at the original setting, it will probably be found after a few months' operation under different conditions of temperature, charging rate, etc., from that for which the equipment was originally adjusted, that the setting of the stop charge relay will be either too high or too low. If it is too low, the battery charging voltage will come up to the setting of the relay before the battery is fully charged and the battery would then never be given a full charge, this would result in sulphation of the plates, which would only make bad matters worse. If the setting is too high, the charging voltage at that particular current rate may never reach the voltage setting of the relay, in which case the battery would come to a full state of charge and then continue to be overcharged excessively. As a matter of fact, as this overcharge is continued the battery will warm up and the charging voltage will actually be reduced and fall farther and farther away from the setting of the stop charge relay.

In several modern axle generator systems which operate on a combination current and voltage principle, the battery is given a final taper charge; the voltage control can be set low enough so as to always operate and the taper charge be relied on for the finish. The objection to voltage relays mentioned do not apply to such systems except to a limited extent.

Ampere Hour Meter Control of Charge.

Prob. 62. Has the ampere hour meter method of controlling battery charge been used successfully to any extent on axle equipments?

Ans. 62. As mentioned in Problem 60, the ampere hour meter method of controlling battery charge has been employed in connection with axle car lighting systems for about a year and is now being used on over 600 car lighting systems in this country.

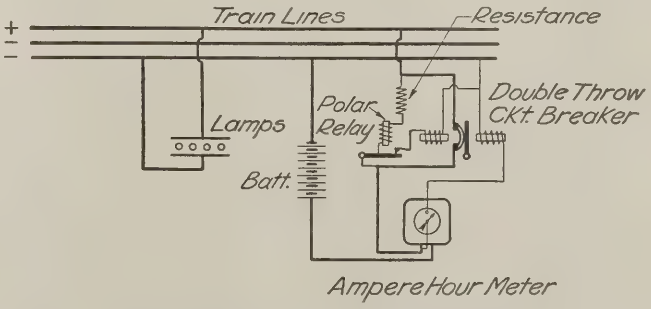
The special design and operation of the various car lighting systems requires a slightly different application of the ampere hour meter on nearly every type of equipment. However, it is safe to say that the ampere hour meter can be used to automatically control the charge given a storage battery with any axle generator system on the market today. In an early lesson of the A. B. C. Car Lighting Course we will work out the details of application of the ampere hour meter principle of control to the various systems and show how it differs in various cases.

Ampere Hour Meter on Head End System

Prob. 63. Can the ampere hour meter be used for automatically controlling the charge given storage batteries on the various cars of a train being lighted by the head end system? If so, how?

Ans. 63. The headend system presents conditions which are far different from those of the axle car lighting system. Here we have one generator supplying current to the lamps of an entire train and also to several batteries, which may be in any condition of charge and will rarely, if ever, be all fully charged at the same time.

Furthermore, all batteries on the train must be available instantly for service when the generator is shut down or the train parted. This means that the batteries must never be entirely cut off the train line. The accompanying sketch shows an idea worked out by one of the members of our staff to accomplish this result. Obviously an ampere hour meter must be placed in each battery circuit to record the charge and discharge of that particular battery. The meter will be constructed so as to automatically provide about 20% excess of charge over the discharge. When the dial hand of the meter gets back to zero it indicates a full state of charge and will make a contact which will operate the circuit breaker, inserting a compara-



Design of Circuit for Employing Resistor Type Meter to Control Charge Given Battery in Headend Service.

tively high resistance in the circuit of that battery.

The battery is not entirely cut off the line, however, so when the generator is shut down and its voltage falls below that of the battery a reverse current will flow through this resistance, provided there are any lamps in use at that time. This reverse current will also flow through the coils of the polarized relay, operating it and closing circuit through the restoring solenoid of the circuit breaker and again short circuit the high resistance, immediately connecting the battery on the line. With this system each battery of the train would be controlled separately, yet all would be available for immediate use whenever required. This system is not patented and any railroad is free to use it.

Overcharging.

Prob. 64. Does overcharging a storage battery injure it?

Ans. 64. It is often advanced as a sales argument that a certain battery is not in any way injured by overcharge. It is a definite fact, however, that when overcharging occurs, the active material within the plates has been entirely converted and the only thing left for this charging current to do in passing through the battery is to decompose the water in the electrolyte, commonly known as gasing.

Water is composed of hydrogen and oxygen, two gases chemically combined, and where the water is decomposed these gases are liberated, not only from the surface of the plate, but from deep down within the active material of the plate itself. This gas being emitted from the body of the active material will tend to mechanically blow out small particles of active material and the bubbles of gas rising across the surface of the plate will have a brushing action, which will also erode the active material, causing a collection of sediment in the bottom of the tank.

Prob. 65. Can you tell from the appearance of the battery if it is regularly receiving too much charge?

Ans. 65. It is rather difficult to tell from the appearance of a battery if it is receiving too much charge. The plates will usually be a fine healthy color, the positive a rich chocolate brown, and the negative a dark slate gray. Where the plates are not being excessively overcharged the tops of the positives should be slightly grayish brown; but where the battery is being seriously overcharged, the positive plates will be a rich chocolate brown on the top as well as over the surface of the active material.

Overcharging is usually accompanied by high temperatures, the battery often being hot when received at the terminal, although this is not always a sure indication of overcharging. If the battery needs flushing more frequently than once in three or four months, or if there is an usually rapid collection of mud in the bottom of the tank, the battery is probably being overcharged.

Percent Battery Efficiency Assumed for Ampere Hour Meter.

Prob. 66. What percentage overcharge in ampere hours should be given a storage battery in order to make up for battery losses and to keep the battery in a full state of charge?

Ans. 66. As mentioned in Problem 62, the percentage overcharge in ampere hours which must be given the battery depends upon the ampere hour efficiency under which that battery is working. The ampere hour efficiency of any battery depends entirely upon the frequency and amount of charge and discharge. A battery, such as a big floating electric railway battery, which one instant may give a heavy discharge, and the next instant receive a heavy charge, the ampere hour efficiency may be as high as 99%. On the other hand, where a battery receives very little discharge and is charged only occasionally, the ampere hour efficiency may be well below 50% or even less. In the first case an overcharge of 1% in ampere hours would be sufficient to keep the battery in good condition, while under the latter condition, an overcharge of 100% of the discharge or more might be required. The majority of the 600 axle equipments now being controlled on the ampere hour principle are set so as to provide an overcharge of 20% of the discharge. Many of these equipments have been so operated for up well under this percentage overcharge.
nearly a year and the batteries seem to be holding

Extensive service and records with the graphic ampere hour meter will no doubt clearly show what this percentage overcharge should be, but as explained in Problem 62 even though the percentage overcharge may be twice as high as it should be, the actual overcharge in ampere hours will be comparatively small and will probably not injure the battery to any serious extent.

Effect of Vibration on Meter.

Prob. 67. Is the ampere hour meter mechanically strong enough to stand the severe conditions of car lighting service?

Ans. 67. The only ampere hour meter on the market today is of the mercury disc type, in which the armature of the meter is simply a copper disc floated mercury. The entire weight of the armature disc, the dampening disc and the shaft to the recording gear train is buoyed upward by the floating effect of the mercury, so that instead of there being a downward pressure on the main bearing there is a slight pressure upward of about 1/10 of an ounce. Accordingly, even the most severe vibration received in railroad service should not injure the bearings of this meter. It would be difficult to break a piece of ice floating in a pail of water by striking the side of the pail—the comparison is analogous with vibration of the mercury meter.

Some of the first ampere hour meters installed in connection with axle car lighting systems proved defective because of the excessive heat within the regulator locker, causing the composition of the meter chamber to soften, with the result that the disc would occasionally bind and the meter fail to record. Recently an improvement has been made in this meter, using condensite for the walls of the mercury chamber, however, and as this is not affected by any temperatures below 350 deg. Fahr., there should be no more difficulty from this source.

Accuracy of Ampere Hour Meter.

Prob. 68. Will it give as accurate results as the battery voltage indication?

Ans. 68. The ampere hour meter method of controlling storage battery charging should give far more reliable operation than the voltage method, for if the voltage setting be 10% too high this may cause a failure of the entire system, whereas, on the other hand if the setting of the ampere hour meter percentage overcharge be even 100% in error it will cause only a slight battery overcharge in ampere hours.

"Floating" a Battery.

Prob. 69. What is meant by "floating" a battery on the line?

Ans. 69. If a battery is connected permanently to a circuit of constant potential of from 2.13 to 2.25 volts per cell (35 to 36 volts for a 32-volt system), the battery will automatically take its own charge, tapering off to a very low value at the end of charge. If a fully charged battery be connected to a circuit of this voltage, as is done in the Consolidated and the U. S. L. systems with ampere hour meter control, the battery will "float" on the line with practically no charge or discharge flowing.

Use of the Pilot Cell.

Prob. 70. What is a pilot cell and how is it used?

Ans. 70. When the specific gravity readings of a battery are taken as a basis for determining its condition of charge, one cell out of the battery is selected and all readings of gravity are taken from this cell, this is called the pilot cell.

A. B. C. Car Lighting Course

Edited by Edward Wray

Lesson No. 35

G. E. Z. (German) Car Lighting System

Few people realize the great number and variety of axle car lighting systems which have been operated in this country and abroad for lighting railway cars. So far in this course of lessons we have described no less than two dozen systems, all operating on a different principle of control, yet all accomplishing virtually the same result, that of controlling generator voltage to approximately constant value, regardless of what the speed of the train and generator may be.

Many of these axle car lighting equipments involve construction radically different from that of any other electrical machinery, but without doubt the equipment described in this lesson represents unusually great ingenuity on the part of the designer.

Generator.

The generator is somewhat similar in the fundamental principles of operation to that described in our lesson No. 22, on the E. S. B. axle lighting system. Unlike the E. S. B. equipment, however, this generator operates to deliver constant current regardless of the potential, instead of constant potential as does the E. S. B. system.

The generator used in this system is known as the Rosenberg machine and was described in our lesson No. 19, of August, 1913. There are certain modifications in the control of the generator, however, which make it advisable to consider certain features of this generator in this lesson. Upon referring to the diagram, Fig. 181, it will be noted that there are two separate magnetic fields in this machine, (1) the primary field produced by the coils FF, (2) the main field of the generator indicated by the heavy curved arrows.

A current of constant value through the field coils FF is maintained by battery voltage and with the armature coils revolving in this field, a potential is generated across the brushes AA. These brushes are directly short-circuited by a heavy load, however, so this voltage simply causes a short-circuiting current to circulate through the coils of the armature and short-circuiting lead. This current circulating through the armature coils is virtually a large solenoid (which is always on an axis perpendicular to the primary field) and creates the main magnetism of the machine which might be called the armature field. This magnetism circulates through the armature and across the pole faces, as shown, none of it passing through the frame of the generator as is customary in the ordinary machine. This secondary magnetism then generates an electric motive force at the brushes BB for the external circuit.

Current for the external circuit flowing through the coils of the armature produces its own armature reactions and these play a very important part in the generator control. For the sake of simplicity we will assume that the short-circuited magnetizing current and the current for the external circuit, although both flowing through the coils of the armature, be considered as on entirely separate circuits. It will be noted that whereas the short-circuited current creates magnetism at right angles to the primary field FF, the magnetism of the external current flowing through the armature creates magnetism which is directly opposed to the magnetism FF, and accordingly diminishes it in direct proportion to the strength of the current in the external circuit.

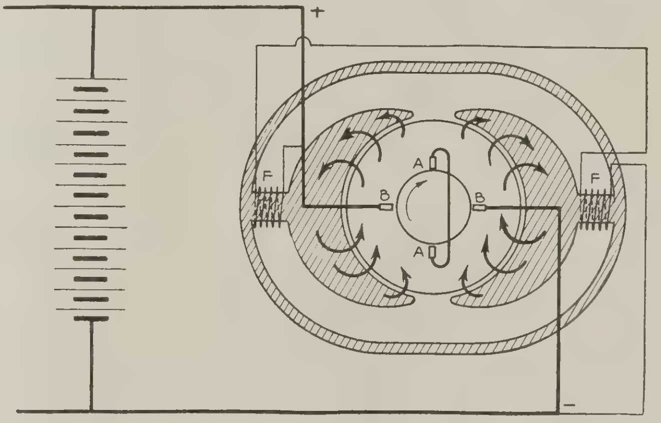


Fig. 181. Diagramatic Representation of the Operation of the Generator Showing Secondary Magnetic Flux.

For a certain value of current in the external circuit then, the ampere turns of its armature reaction would be exactly equal and opposed to the ampere turns of the primary field FF and the resultant magnetizing flux would be zero. With the primary magnetism zero, however, there would be no voltage developed across the brushes AA and no magnetizing current for the armature field. So it is evident that the current through the external circuit can never be greater than a certain value which allows the ampere turns of the primary field FF to be slightly greater than the ampere turns of this armature reaction.

As the speed of the generator increases, obviously the main armature field must decrease and to do this the difference between primary field ampere turns and armature reaction ampere turns must decrease correspondingly. Since the ampere turns of the field FF are practically constant, this change in magnetism must be brought about entirely by an increase in external current. This increase would be very slight, however, since a comparatively small variation in the current of the external circuit will produce a big variation in the difference between this magnetism of armature reaction and that of the primary field.

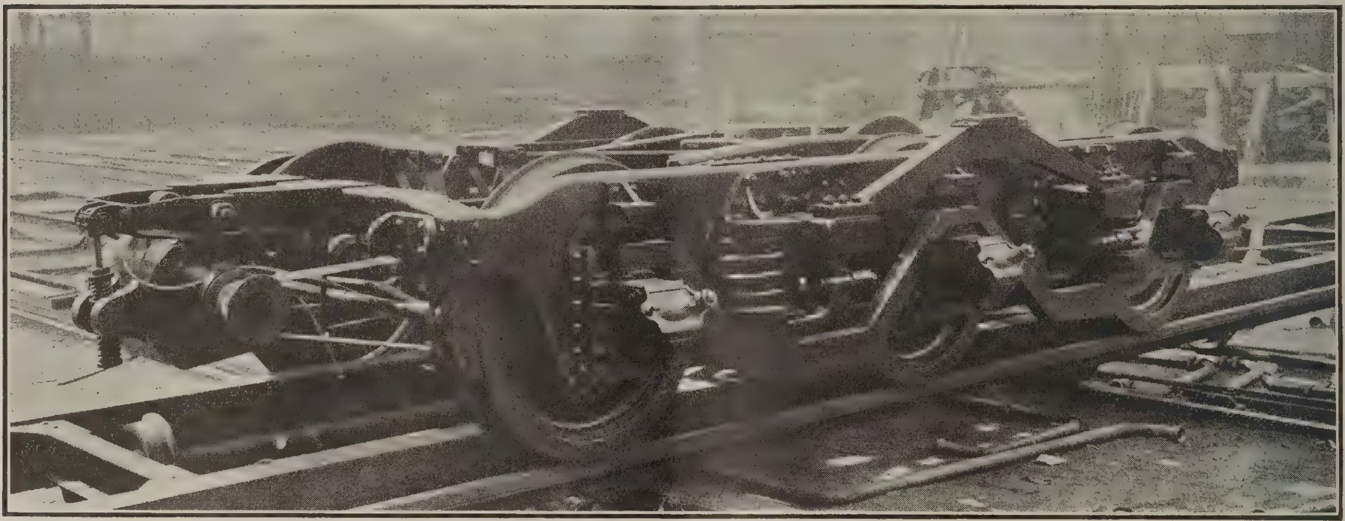


Fig. 183. Rosenberg Generator Suspended from Special Cantilever Beam Mounted on End Sill.

On reduction in train speed the principal magnetism of the machine must increase correspondingly and in order to bring this about, the current to the external circuit must decrease slightly in order to allow the primary field FF to increase the magnetizing current of the armature field.

Pole Changer.

Upon reversal of the direction of motion the potention across the brushes AA will be reversed and this will cause the short-circuited magnetizing current of the armature field to be also reversed. With a double reversal of direction of rotation and polarity of the main field, the polarity of the brushes BB will always be maintained constantly regardless of direction of rotation. This generator then does not require any pole changer as it automatically maintains proper polarity.

Lamp Regulator.

Ballast resistances made up of iron wire in glass bulbs are used to absorb the variations in dynamo voltage and maintain current flowing through the lamps at practically constant value, which ensures constant lamp voltage. It is well known that the resistance of an iron wire at about dull red heat increases greatly with a slight increase in temperature. With an abnormally high dynamo voltage, due to battery charging, excessive current would tend to flow through the lamps. A slight increase in the current through lamps and ballast resistance, however, will cause the temperature of the iron wire to rise considerably. This will greatly increase its resistance and will compensate for the rise in voltage and maintain practically constant lamp voltage. Where lamps have individual control, such as berth lights, these resistances are placed in each lamp circuit. Where several lamps are operated on the same circuit the iron wire resistances are connected in multiple, as shown in the diagram.

Voltage Limiting Device.

As explained above, the generator will regulate for constant current output regardless of voltage. In order to prevent the full current being forced into the battery after it has become charged, a voltage limiting coil is provided, as shown in the diagram, Fig. 182. When the generator voltage rises to a value at which this coil is set it will lift its plunger and insert the resistance "S" in the generator field circuit. This will cause the primary magnetism of the generator to be reduced to a low value and the generator output will be reduced to about 5 amperes. The manufacturers state that if the voltage coil does not happen to be set at the proper value, or fails to work, the over-

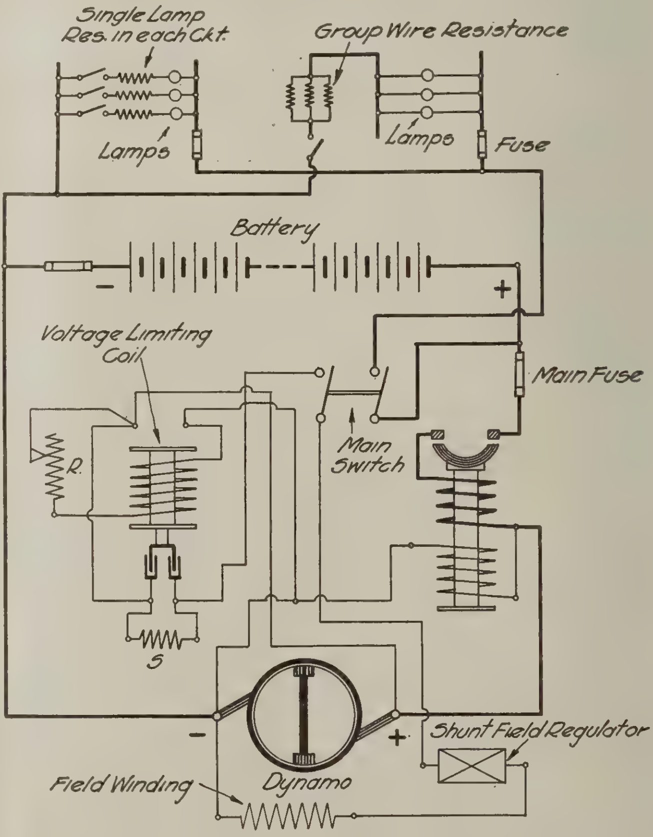


Fig. 182. Wiring Diagram of the G. E. Z. System.

charging will be easily indicated by the fact that the battery needs frequent flushing.

General.

The G-E-Z system the Gesellschaft für Elektrische Zugbeleuchtung m. b. h. (The Electric Car Lighting Company, Ltd.), which furnishes this type of construction, is a consolidation of the three electrical firms, Accumulatorenfabrik Aktiengesellschaft Berlin-Hagen i. W., Allgemeine Elektrizitats-Gesellschaft and Siems-Schuckert-Works.

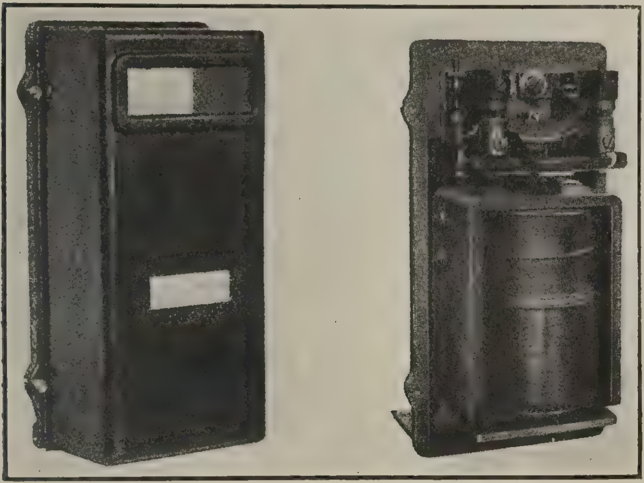


Fig. 184. Automatic Switch with Cover Removed.

At the present time there are about 3,500 cars equipped with this system of car lighting. These are operated chiefly on the Prussian State Railways, although many are in use on other German, Austrian, Russian, French and Turkish railroads.

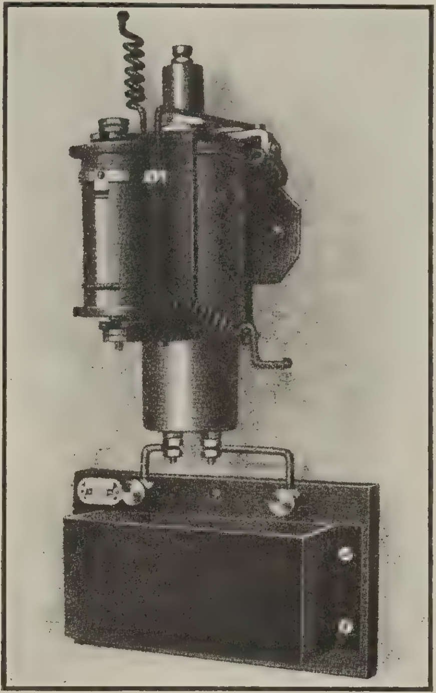


Fig. 185. Voltage Limiting Relay.

We are indebted to Dr. Max Buttner, of Berlin, Germany, for the information contained in this article.

Prize Question Box

This "Question Box" is open to every electrical man in the Mechanical, Signal and Telegraph, as well as Car Lighting Departments. We feel that this can be made a mighty valuable thing, so as a special inducement to the boys to boom it, we offer prizes for the best questions asked, as follows:

First prize ....$1.00 *in cash*
Second prize ....9 *months' subscription*
Third prize ....6 *months' subscription*

There are some questions that are of a general nature, which should have comments of prominent men of experience. These will be published under "Questions Before the House," and we hope that prominent railroad men and manufacturers will discuss these questions. All answers published will be paid for at $1.00 *each.*

Influence of Battery Charging Current on Lamp Voltage U. S. L. Pullman System.

I am referring this question to you for a decision as the matter has been the subject of a dispute among some of us lately.

A car arrived in the yard with lights reported dim. The report did not state whether or not the lights were poor while running or standing. The car was given an inspection but nothing wrong was detected with the equipment. This was a U. S. L. panel, in which a resistance had been inserted in place of the type H relay, as shown in Fig. 173 of your lesson No. 32, for September 1914. When this unit was applied the voltage on the lamps was carefully adjusted and the battery charging pin set in the third hole. Upon closer inspection, after trouble was reported it was found that the charging pin was in the fourth hole. The pin was dropped to the third hole and the car has been running O. K. ever since.

From my own experience on other similar equipments I have found that where the output had to be increased or decreased by raising or lowing the adjusting pin, it became necessary to move the contact pin at the middle of the resistance R, Fig. 173 to the right or left about ¼ of an inch, according to which way the pin was moved, in order to maintain proper lamp voltage regulation.

"A" claims that moving the charging pin should not affect the voltage on the lights, "B" claims it will—what's the answer?
—F. C. L., Jersey City

(*Won't F. C. L. advise us of his name and address; he draws the dollar prize*).

Ans. Upon referring to the diagram, figure 173, published in our September lesson, it will be noted that the contact point at the middle of the resistance (R) connects with the tail piece of the automatic switch. When the switch is open this lead is dead and the current through the lamp regulator solenoid must flow through the entire resistance (R). When the automatic switch closes, however, this contact short circuits the segment (b) of this resistance and increases the current flowing through the solenoid of the lamp regulator, causing a corresponding increase in the resistance of the regulator carbon pile so as to compensate for the rise in voltage across the lamps as the automatic switch goes in.

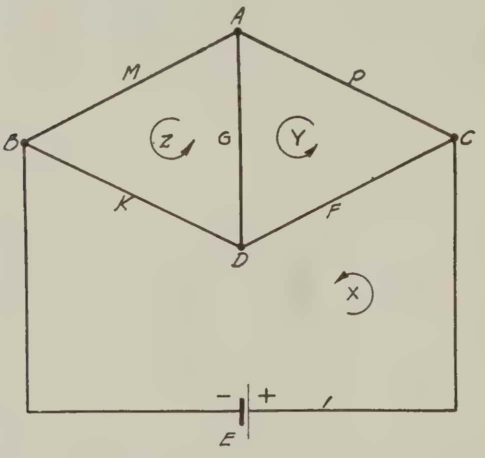
With a charge of say 20 amperes flowing into a battery, the terminal voltage of that battery will be a few volts higher than the terminal voltage of the same battery the next instant, with 20 amperes current flowing in a discharge direction. It is this difference in the voltage between discharge and charging conditions that the short circuiting of the segment (b) of resistance (R) is designed to compensate for. The heavier the current flowing, the greater will be the difference between the voltage on charge and on discharge, and accordingly, the ratio of resistance (b) to the whole segment of the resistance (R) should be increased with an increase in the battery charging current; so "B" is right in his argument.

The contact ring on the middle of resistance (R) does not have to be adjusted to an exact point, as the lamp regulator ought to be able to adjust the lamp voltage to the correct value, even though this is not set exactly right, but it should be set as near right as possible in order to allow the lamp regulator control the voltage with the greatest accuracy. This feature of short circuiting the resistance (b) decreases the voltage range over which the lamp regulator must operate and increases its sensibility within that range. —Editor.

Solving Complex Circuits

In applying Ohms Law to the solution of divided circuits I came upon the following problem which I would like to know how to solve. In the accompanying figure, assuming a potential of 100 volts between the wires M M', what current will flow in each of the 5 branches, A. B. C. D. & E. if their respective resistances are 20-5-10-25-35 ohms.

Fred Loweth, Buffalo, N. Y.



The circuits shown in the diagram constitute a so called Wheatstone bridge. The current distribution may be solved by purely algebraic methods, by Maxwell's rules for the solution of networks and by other devices. Algebraic methods become somewhat involved and are usually not as easily handled as the methods developed by Maxwell a few years prior to his death, which occurred in 1879. In the following I will give a brief outline of Maxwell's method and its application to the problem submitted.

A real current may be expressed as the sum or difference of two imaginary currents as 7-6 amperes equals 1 ampere. The signs before the quantities may be taken to represent direction. Thus—4 amperes added to —3 amperes = —7 amperes. The real current is 7 amperes and its direction of flow is opposite to the direction arbitrarily called positive.

In Fig. 1 assume in each mesh imaginary currents x, y, z, called "cycles." Assume these currents circulating counter clock wise, which direction Maxwell calls positive, probably on account of mathematical uniformity. The real current in AD is equal to the difference between the Z cycle and the y cycle. The subtraction is made algebraically giving the cycles their proper signs. In Fig. 1 the battery is connected so that its cycle x is positive, producing positive cycles y and z in their respective meshes. An e. m. f. tending to produce a negative (clock wise) cycle is given a negative sign.

An outer mesh is one having at least one side composing an outer border of a network. All meshes in Fig. 1 are outer meshes. An inner mesh is one completely enclosed in other meshes. The current in the outer lead of a mesh is always equal to the value of the cycle.

The symbols of the cycles (x, y, etc.) are the bases of simultaneous equations, one equation being written for each mesh. At least one of the equations has a known quantity in the form of an e. m. f. in one of the expressions. The equations are solved by ordinary algebra for the values of the cycle symbols. By subtracting the cycle values for inner leads and by taking them as they stand in the case of outer leads, the values of the real currents in the most complicated circuits are determined.

In cycle equations the mesh enclosing the cycle is treated as a closed electric circuit. If a generator of e. m. f. is included in the circuit the expression is equated to the value of the e. m. f. of the generator. If there is no generated e. m. f. in the circuit of a cycle the expression is equated to zero.

Referring again to Fig. 1, consider just the x cycle. If r represents the resistance of the complete battery circuit BEC and m, p, q, k and f the resistance of the legs of the network we have by ohms law

$$rx + f\,(x-y) + k\,(x-z) = E \quad (1)$$

In the case of the y circle there is no included e. m. f. hence:

$$py + q\,(y - z) + f\,(y - x) = 0 \quad (2)$$

and the z cycle:

$$mz + k\,z - x) + q\,(z - y) = 0 \quad (3)$$

Grouping terms and writing the simultaneous equation we have:

$$\begin{gathered} x\,(r + f + k) - yf - zk = E \\ -xf + y\,(p + q + f) - xq = 0 \\ -xk - yq + z\,(m + k + q) = 0 \end{gathered}$$

The values of the resistances and the voltage may now be substituted and the equations solved algebraically:

In the case of the problem at hand we may take the values as follows:

A = k = 20 ohms
B = m = 5 ohms
C = q = 10 ohms
D = f = 25 ohms
E = p = 30 ohms
r = 0 since we are solving the Wheatstone bridge circuit only.

$$\begin{gathered} x\,(0 + 25 + 20) - y\,(25) - z\,(20) = 100 \\ -x\,(25) + y\,(30 + 10 + 25) - z\,(10) = 0 \\ -x\,(20) - y\,(10) + z\,(5 + 20 + 10) = 0 \end{gathered}$$

or:

$$\begin{gathered} 45x - 25y - 20z = 100 \\ -25x + 65y - 10z = 0 \\ -20x - 10y + 35z = 0 \end{gathered}$$

Since all terms are divisible by 5 the equations may also be written:

$$\begin{gathered} 9x - 5y - 4z = 20 \\ -5x + 13y - 2z = 0 \\ -4x - 2y + 7z = 0 \end{gathered}$$

Solving we find:

x = 5.436 amperes (= total current at 100 volts)*
y = 2.688 amperes
z = 3.875 amperes
Current in A = x − z = 1.561 amperes
Current in B = z = 3.875 amperes
Current in C = z − y = 1.187 amperes
Current in D = x − y = 2.748 amperes
Current in E = y = 2.688 amperes

Arranged for positive current values only.

For general data on calculations or networks, see Sloane's "Electrical Calculations."

F. G. Beetem, Philadelphia, Pa.

---

*The total resistance $= \dfrac{100}{5.436} = 18.4$ ohms

Practical Stunts

We Pay a Dollar Apiece for Practical Stunts—Send in Your Ideas

Test for Automatic Switch on U. S. L. Machine.

This stunt I have used to good advantage on a U. S. L. machine to test the lifting coil of the automatic switch and the resistance unit which connects the lifting coil in series when the triple contact screw leaves the top of the automatic switch and breaks the circuit of the unit. First remove the fuse from the main circuit on the panel board and be sure that the field circuit fuse is in good condition and in place, then take a piece of wire or a pair of pliers and connect the positive battery to the positive field terminal, the switch will immediately close if the contact screw is making proper contact. If it does not close, this screw should be removed and the contact cleaned, when it should operate satisfactorily. If the switch then does not close or tend to close, an open circuit is indicated in the lifting coil.

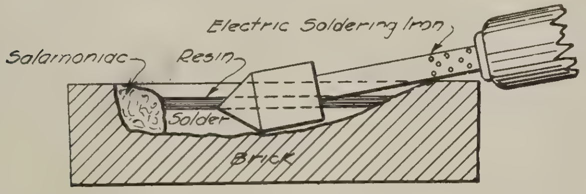
To test the resistance unit you proceed in the same manner. If the circuit is open the switch will close and drop out very quickly, giving a heavy blue spark at the triple contact of the automatic switch. If it is O. K. the switch will cut in and stick, or in some cases open and close slowly, indicating that both the lifting coil and the resistance are right.

C. Gudehns, Woodbridge, N. J.

Tinning Block for Electric Soldering Tool.

This tinning block I have found to be very helpful for use with an electric soldering iron. It is made by scooping out the top of a soft brick and placing the tinning material in this cavity. Into one end of the brick, as shown in the sketch, a lump of salamoniac is placed to help tin the copper bit. Some solder is then run into the hollow and finally enough resin is put in to nearly fill the cavity.

When it is desired to retin the tip of the tool it is rubbed on the brick below the solder, which scrapes off all oxide. When not in use, the tool is allowed to remain in the solder—keeping it in a molten condition. One can tell when the copper bit becomes too hot by the volatization of the resin, thus calling attention to the fact, whereupon the current is turned off until the tool has cooled to the proper temperature.



F. G. Phipps,
Hochelaga, Montreal, Canada.

Use for Wornout Wrench Sockets.

Quite often the hexagonal sockets of an axle pulley wrench become worn so that they are no longer useful, and they are scrapped. I have found a way to use these sockets very nicely for tightening up ball bearings. This is done by reaming out the socket to fit the taper of the armature shaft and then slotting same for the armature key. You are then able to tighten your ball bearings by use of the same ratchet wrench which you use on your axle pulleys, it being necessary only to change the socket.

W. C. Burgess, Santa Fe, Los Angeles.

Standardization of Crane Motors

To the Editor:

Having had considerable experience in the handling of problems relating to installation of electric cranes in railroad shops, I was very much interested in your editorial on Standardization of Motor Sizes for Travelling Cranes, published in the October number of the Railway Electrical Engineer.

A perusal of Table X included in the report of the Committee on Data and Information, Association of Railway Electrical Engineers, gives information regarding motor sizes on cranes which have been installed in railroad shops during a period extending from the earliest application of electricity for operating cranes to the present time. The writer also recognizes in the list, two rope driven cranes, marvels of mechanical ingenuity, which were installed in 1883 and to which he applied 15 horsepower constant speed alternating current motors in 1908.

The above ancient history is presented simply to show that the data presented in the table is simply a record of motors on cranes installed in railroad shops during a period of somewhat over thirty years and as such does not represent either present day practice or requirements.

The determination of crane motor sizes for a definite duty, as practiced by most manufacturers who make the construction of cranes their specialty is no longer a matter of guesswork but follows definite and uniform lines based on extended experience with the requirements of crane operation. In the purchase of electric cranes, if the hoisting, bridge and trolley speeds are specified, in addition to data regarding the duration and frequency of hoisting cycle, the writer believes that very slight if any variation will be found in the sizes of motors recommended by the various manufacturers.

In the purchase of a number of cranes for use in any one shop, the writer, for some time past, has followed the practice of tabulating the horsepower and speeds of motors on the various cranes and then making such adjustments in the power rating only as would give a minimum number of sizes, consistent with the number of motors involved.

The writer believes that consideration of the subject of crane motor ratings by a special committee would be productive of beneficial results in that definite information regarding the current practice of rating motors for cranes, and suitable hoisting, bridge and trolley speeds for various operations would be made a part of the association's proceedings.

Willard Doud, Consulting Engineer.

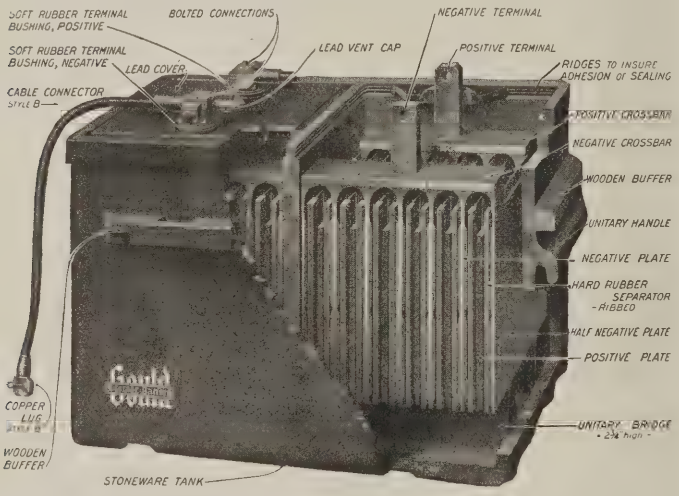
With the Manufacturers

New Stoneware Battery Tank

The Gould Storage Battery Co. has recently brought out a stoneware tank which is now in use on a number of railroads throughout the country. This tank is the result of nearly fourteen years of experiment and, so far, has proven entirely satisfactory.

The present tank, which is a double compartment unit, is moulded under great pressure, then glazed and annealed in the kiln. The result is a material of remarkable tenacity and which is absolutely impervious to action of the electrolyte.

Inasmuch as the tank in itself is an insulator, it allows the discontinuance of the use of rubber linings for the ends and the sides and of the brittle porcelain bridges now required in the present standard lead lined tank. Furthermore, the bridges and the handles are moulded with the tank so that the entire containing compartment is a unit. Wooden buffers are held by special moulded projections. The bottom of the tank is moulded in such a manner as to obviate the necessity of skids or rollers. This allows an extra containing space to be used for additional acid over that possible in a lead lined tank with the same size of plates. The extra space is utilized between the bottom of the plates and the bottom of the tank, thus allowing sufficient room for all the sediment thrown off during the life of the plates and also allowing the same overhead space for acid as in the present standard tanks.



Stone Ware Jar Partly Broken Away, Showing Arrangement of Plates.

One of the interesting features is the saving of upwards of forty-nine parts for one double compartment tank, a great number of these parts being subject to renewal.

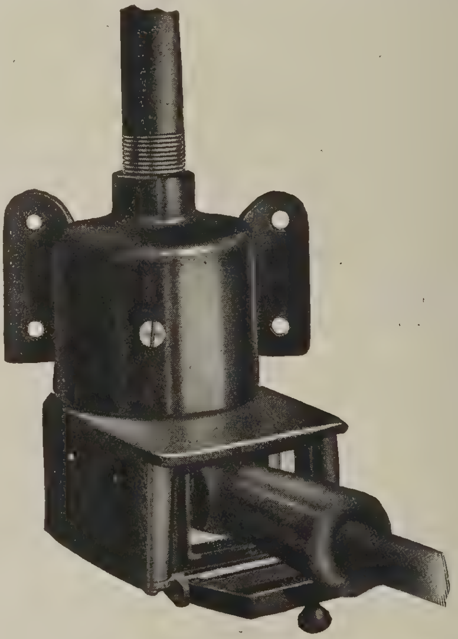
Another point worthy of comment is the absolute absence of all metal parts, such as brass screws, steel handles and such parts subject to corrosion from the acid fumes.

Among other advantages claimed for this design of tank, is the large increase in the volume of electrolyte over the present standard. This, with the natural tendency of the stoneware jar to radiate heat, prevents excessive heating of the electrolyte and not only materially reduces the amount of flushing found necessary with the present standard of lead lined wooden tanks, but also prevents the wide variations in the specific gravity of the electrolyte.

New Ralco Swivel Type Receptacle

There are many conditions under which receptacles and plugs are used in railroad service where the rigid receptacle hardly meets all the requirements. Accordingly, the swivel type No. 20 Ralco receptacle has been designed for use in any service where the plug is apt to be accidentally withdrawn.

This consists of the standard cast iron Ralco receptacle, which is mounted below a special cast iron swivel support. The receptacle may be easily removed from the swivel mounting for wiring up to two binding screws. The cast iron top is tapped for ¾ in. conduit, and is arranged for attaching to pillars, posts, walls, etc., by the means of two projecting lugs.



New Swivel Receptacle.

The moving parts of this swivel receptacle are made of ebony transite, the current being carried by two heavy copper rings, one mounted on the upper and one on the lower transite disc, these rings being so arranged that they are in constant contact over their entire surface regardless of the position of the swivel.

The receptacle is fitted with spring door, thus making it weatherproof and suitable for outdoor use. This can also be furnished without the spring door, and is then known as No. 20-A. Its capacity is 30 amperes, 220 volts, and the reversible plug No. 1 is bored to take all sizes of Okonite Portable Cord up to and including No. 8 B. & S. gauge.

This receptable and plug is especially adapted for use in roundhouses, machine shops, on freight loading platforms, and all places where portable lamps or machines are used, because of the fact that it requires no attention as the tool or lamp is shifted from one position to another. Accidental injury to power service line is impossible as the swivel mechanism will follow every movement and the plug be withdrawn by a straight pull.

Testing Insulators

The Western Electric Company's engineering department at New York is conducting an interesting comparative study of pole line insulators. Over three thousand insulators, of different shapes and materials, are mounted on a low roof in one corner of the West Street building, as shown by the accompanying photograph.

Insulator Testing Rack.

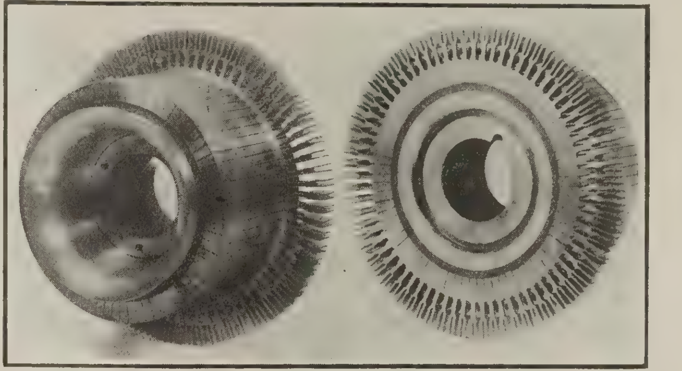
A special selective mechanism is mounted on a pole near the centre of the insulator rack which permits the insulation resistance of each group of insulators to be measured with instruments located in the physical laboratory. The laboratory is several hundred feet away and only a few very heavily insulated wires connect the "selector" to the laboratory.

Dust from the street and smoke and soot from nearby factory chimneys gradually accumulate on the insulators and their insulation resistance measured during wet weather decreases. The ability of the insulators to maintain high insulation under these severe conditions determines their relative merit for telephone and telegraph service.—*Western Electric News.*

New Commutator Construction

The U. S. Light & Heating Company of Niagara Falls, N. Y., have recently placed upon the market a very novel construction of commutator for use in their axle lighting generators. The construction of this commutator eliminates all bolts, screws, nuts and fastenings of all kinds. The bars are insulated from one another by the usual mica segments, but the insulation between the reinforcing rings, sleeves and bars is made of bakelite, which is formed under enormous hydraulic pressure and holds the bars in position more rigidly and securely than is possible with any of the older methods of screw and bolt fastenings that have been employed.

A commutator constructed in this new manner can never become loosened, or the bars dislodged, nor can high bars or loose bars ever be the result of operation. The bakelite will not soften or expand under heat, and, therefore, the commutator will always retain its original true and round form. There being no threaded fastenings or locking devices of any kind used in the construction of this commutator, there are none of these things to get loose or cause any anxiety to the operating man, and he may feel assured that one of these commutators will last until the copper segments are completely worn out.



Commutators Insulated with Bakelite.

Tests made to determine the strength of these commutators show that a large margin of safety is secured at speeds far beyond those possible in railroad practice. A train speed of 500 miles per hour would not endanger the commutator in the slightest.

The U. S. Light & Heating Company proposes to adopt this construction as its standard and will be prepared to furnish these commutators on all sizes of its generators in the near future.

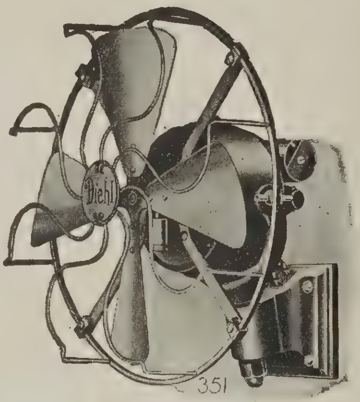
Union Carboy Inclinator

A carboy inclinator has recently been put on the market by H. M. McCord Company, Lumber Exchange Bldg., Minneapolis, which will be of interest to our readers. A tray, which may be tilted to any desired angle, is supported on a wooden frame and when it is necessary to remove some of the acid from the carboy it can be tilted very easily, since the point of support is only slightly above the center of gravity of the solution. At the front of the box a hinged drop gate is provided which can be lowered when it is necessary to remove or install carboy. In service this gate is raised and supports the bottom edge of the carboy. A safety key, shown on the upright standard, prevents the carboy from tilting, except when it is desired to remove acid.

At the back of the carboy is an adjustable steel clamp rod with broadened head which is brought down above the upper rear edge of the carboy. This clamp rod is adjustable through a vertical range of eight inches and its curved head extends inward five inches so as to permit engaging the top of carboys of any size. The clamp arrangement for this rod is shown in Fig. 1. By means of a lever bar the rod can be instantly adjusted and when forced down the bar is retained by a spur which engages a saw-tooth plate secured to the rear wall. This firmly holds the

The House

Our ability to make immediate shipment from an immense
to your orders. Your entire requisition for electrical
one order and you receive the goods in one shipment. Think



Diehl Car Fans, pleasing in design, give a finishing touch to passenger comfort. They have been designed especially to meet the severe conditions of railroad service. The fan body is readily removed from the base without disturbing the wiring. Furnished in all standard voltages and also 30-60 volt combination. In ordering specify voltage.

DELTABESTON WIRE
REG. U.S. PAT. OFF.

"Deltabeston" Magnet Wire

is used by many roads for rewinding fields and armatures of

Electric Headlights

The insulation is pure asbestos fibre, impregnated.

It won't burn out.

Neither is it affected by moisture.

Can be supplied in all sizes; either flat or round.

Central Elect

320-326 S. Fifth Ave. "The House

# of Service

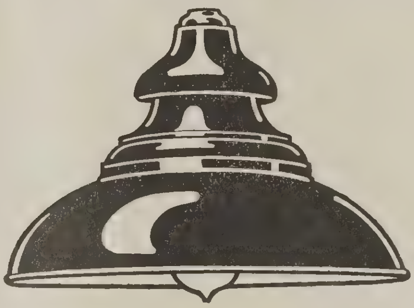
stock of the best electrical material ensures prompt attention supplies on any job, no matter how large, can be covered with of the convenience!

OKONITE
TRADE MARK.

Insulated wire for railway signals, car lighting, shop and terminal light and power service must be absolutely dependable and have the highest insulating qualities — this is just another way of specifying Okonite. It has for years been the standard in railway service.

Okonite Insulation contains never less than 30% of the best quality dry, fine, up-river Para rubber and is made in but one grade, only—**The Best.**

The MAXOLITE



For

Type "C" Lamps

A *one piece* ventilated Maxolite with type "R" fitting.

For use in

Shops	Trainsheds
Yards	Roundhouses
Platforms	Warehouses

Ask for Bulletin 43

ric Company

of Service"

Chicago

clamp rod in position and, as shown in Fig. 2, the rod keeps the carboy in place when the outfit is tilted.

In order to incline the carboy the safety key at the right is withdrawn. The center of gravity is so adjusted that even then the carboy is well balanced. It requires little effort, however, to tilt the carboy and permit withdrawing any quantity of the liquid. One man can easily do this, even to draining out the very last of the acid. All metal parts of the outfit are heavily painted. The entire equipment is shipped in knock-down condition, so as to make a compact crate.

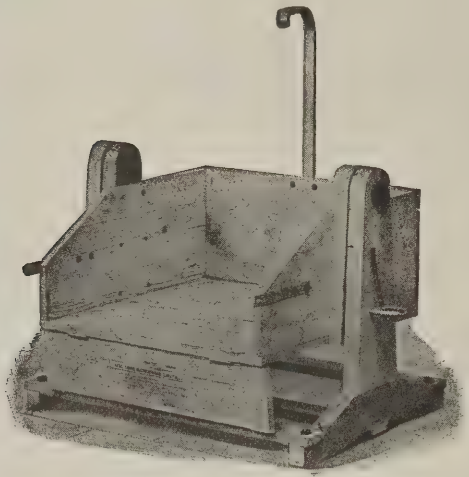


Fig. 1. Carboy Inclinator Showing Hook Which Secures Carboy in Place.

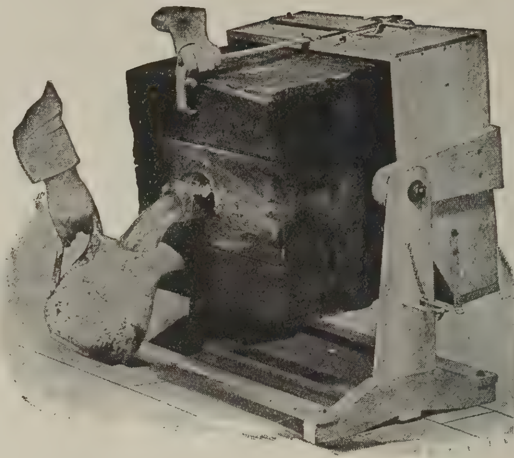
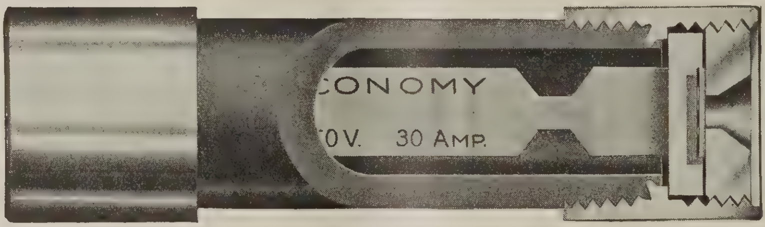


Fig. 2. Note the Rod Which Holds the Carboy in Place When Tilted.

Pullman Company Takes Over Car Lighting on Pennsylvania Railroad Pullmans.

On December 1st the Pullman Company took over the maintenance and operation of the electric car lighting equipment of Pullmans operated on the Pennsylvania Railroad. This involves the operation of all the Pullman cars on the Pennsylvania Lines both East and West. These cars are practically all equipped with 30-volt axle generator devices.

POSITION WANTED as railroad shop electrical maintenance man. Experienced in general shop electrical work, headlight repairs and wiring. Have worked on car lighting and battery overhauling. Letters of recommendation furnished on application. Address W. S., care Railway Electrical Engineer, Chicago.



Ferrule Type

ECONOMY renewable cartridge FUSES

Save 80 per cent annually in fuse maintenance cost, both in the plant and on the cars.

Proof is in Use—Send in Coupon →

ECONOMY FUSE & MFG. CO.
Kinzie and Orleans Streets,
CHICAGO

Economy Fuse & Mfg. Co.,
Kinzie and Orleans Streets, Chicago
Please send Catalog 4, list of users and samples
for..........amps ....volts.

RAILWAY
ELECTRICAL ENGINEER

Official Journal
of the Association of Railway Electrical Engineers.

PUBLISHED MONTHLY BY

WRAY PUBLISHING CO.

EDWARD WRAY,
President.
C. D. SPERRY.
Assoc. Editor.
ADVERTISING BLDG.—123 W. MADISON ST.
CHICAGO.
Telephone, Randolph 7414.

Entered as second-class matter, August 6, 1909, at the Post Office at Chicago, Ill., under the Act of March 3, 1879.

TERMS OF SUBSCRIPTION
United States, Canada and Mexico - - - - Per Year, $1.00
Foreign - - - - - - - - - - Per Year, $1.50

Table of Contents

Editorials— Page
Progress in Electric Traction........................251
Prosperity in the 5% Advance in Freight Rates......251
Last Year's Progress in Electric Traction...............252
Electric Operation of the B., A. & P. Ry.—By J. B. Cox..253
Penn. R. R. Tests Storage Battery Car...................255
C., M. & St. P. Electrification; Some Additional Notes on Power Supply and Conditions Encountered.......256
The Graphic Ampere Hour Meter in Car Lighting Service..258
Million Volt Testing Transformer........................261
Automatic Battery Charging Current Regulator.........262
Railroad Electricians' Club...............................262
Shop Motor Section; Interpole Direct Current Machine.—By J. H. Wickman...................................265
A. B. C. Car Lighting Course; Lesson No. 36, Safety Type "F" Equipment..............................266
Prize Question Box..270
Practical Stunts...271
Manufacturers' Section...................................273
Association Directory..................................... 17

Progress in Electric Traction

During 1914 the progress in the electrification of steam railroads has been characterized by steady and continuous development. Although no startling general electrification has been carried out what has been done is a definite step forward. With all Europe embroiled in war, plans for electrification have been somewhat upset; nevertheless with hardly an exception, every country in the civilized world has increased its miles of electrified line during the year. This growth will be still more noteworthy as soon as data, showing the great saving that can be effected, is available.

At the present time in this country we are using both direct current and single phase power for electrifying roads. The direct current is used at a high or moderate voltage and single phase distribution may be used with locomotives fitted with commutator type motors, split phase locomotives or the rectifier locomotives. In Europe the three-phase system has a large number of adherents. Whether one system will ever be universally accepted in preference to another it is at present impossible for anyone to say, and the next few years will undoubtedly see each standardized and their particular advantages demonstrated.

The operation for the past year of the B. A. & P. shows what may be saved by electrification. The earnings on the investment for this period being over 20 per cent and the saving on coal and power 12½ per cent. Even conceding that these figures are obtained under favorable conditions of cheap electrical power compared with high priced coal used in engines, the saving in the future on this road will be even greater than this after the men have become thoroughly familiar with the electrical equipment.

Prosperity and the 5% Advance in Freight Rates

That the recent 5 per cent advance in freight rates granted the eastern roads will be a guarantee of the immediate return of prosperity, as the daily press has argued, is undoubtedly carrying the point too far. There is no doubt, however, that this will have a material influence on improving business conditions. The American railroads represent the biggest industry in the world next to American agriculture, and it is not surprising that the loss of confidence of the investing public in railroad securities, due to legislative persecution on the one hand, and very questionable methods of financing by certain railroad managements on the other, has resulted in a depression in the railroad securities market, which has indirectly affected all American business.

The increase of 5 per cent in freight rates granted the eastern railroads on all commodities except a few items will result in an increase of net earnings of from $30,000,000 to $40,000,000 a year. At the present time of the year the movement of traffic is light so the influence of this increased earning power will probably not be felt for a few months. It is at once evident, however, this increase of earnings when capitalized at 6 per cent will represent a buying power of from $500,000,000 to $660,000,000, and the railroads will now be able to buy some much needed materials and bring their equipment up to proper standard.

The indirect effects of this increase, however, will be far greater than any direct effects. The investing public all over the world had begun to lose confidence in the securities of the American railroads, both on account of bad financing and acts of legislatures, and it was very evident that if expenses continued to increase and receipts continued to be decreased, or even remain the same, it would not be long before the American railroad securities would be a poor investment. In its decision, however, the Interstate Commerce Commission has shown that its policy is one of constructive regulation, in that it considers the needs of the railroads as well as the demands of the public. A restored confidence in railroad securities by investors both in this country and abroad, will undoubtedly result and railroads will be able to finance new improvements and extensions in a reasonable manner. When the railroads have more money to spend they will buy more equipment and employ more men. This will have a direct stimulating influence on all American business, for there is probably no line of commercial enterprise which is not affected directly or indirectly by the prosperity of the railroads.

In an average year railroads buy over $50,000,000 worth of electrical equipment. The past few years have fallen below this figure, but prospects for 1915 are exceedingly bright, and the purchases of electrical equipment this year will doubtless be two or three times this amount.

Last Year's Progress in Electric Traction

The past year has been one of continuous and steady development, and while no great projects have been completed, still the work done has been of far-reaching importance. It saw the reduction to practice of the split-phase system for electric locomotives on the Elkhorn-Bluefield electrification of the Norfolk and Western. The Canadian Northern Tunnel and Terminal electrification followed in the footsteps of the Butte Anaconda and Pacific 2,400 volt d.c. electrification and the plans of the C. M. & St. P. call for similar equipment except that the voltage is raised in this case to 3,000 volts.

Single Phase Development.

The latest a.c. development is well characterized by the Elkhorn-Bluefield electrification. This development lead to a form of control different from that ordinarily employed with heavy electric traction equipment. The most unique feature of the control is the liquid rheostats which provide for exceptionally smooth acceleration even with heavy loads and at the same time provide a ready means for balancing the load between units having drivers of slightly different diameters.

Lines out of Chicago, New York and Spokane have all adopted single phase compensated motors with notable success. Another single phase installation from Philadelphia to Paoli is radiply nearing completion.

At present the different methods of single phase electrification open to a railroad intending to electrify its lines is confined to one of the three following systems: it may use the commutator type motor; second, the split-phase locomotive may be selected, or lastly, it may choose a rectifier locomotive with rectifiers and single phase transformers.

The single phase motor has been improved in design by the introduction of motors without resistance leads and simple control.

D.C. Systems.

The favorable operation of the B. A. & P. was a very important factor in influencing d.c. electrification. The Canadian Northern electrification mentioned above used direct current after a careful study of all existing installations had been made. The greatest indorsement of the d.c. system was the recent decision of the C. M. & St. P. to electrify an entire engine division using 3,000 volts.

A number of railroads during the past year complimented their steam equipment with gas-electric cars for use on branch lines where traffic is light and for connecting lines between railroads. The reliability and economy of these cars has more than justified their use. Most of these cars have been fitted with 600 volt equipment and have a total motor capacity of 200 h. p. Storage battery cars have been used to some extent for the same class of service and due to improvements in the construction of the storage battery their range of operation has been increased so that they are capable of extended runs without the necessity of recharging.

During 1914 the practical operating characteristics of the metal mercury-arc rectifier were demonstrated. With the co-operation of the Pennsylvania railroad a combination baggage and passenger car was equipped with rectifiers and d.c. motors to 1,000 h.p. total capacity. After satisfactory preliminary operation extended tests were undertaken to determine the effect of sustained operation at high voltage, durability of units under severe conditions, influence of large capacity systems, etc. This car has been operated satisfactorily over 20,000 miles and is at present in service on a run requiring 240 miles per day.

In d.c. railway motor construction, a development promising great advance has been introduced in the shape of a 40-50 h.p. motor with a pressed steel frame. This pressed steel frame is only one of a number of applications of pressed steel in railway motor design, which have been undertaken during the year.

Experimental motors and control have been developed for operation at pressures as high as 7,000 volts. In this connection it is interesting to note that there have been a number of extensions to existing 1,200 and 1,500 volt lines as well as some new lines that have been electrified on this basis.

Locomotive Construction.

In small locomotives the barsteel frame has increased in favor, and is now standard on mine and industrial locomotives up to and including 18 tons. Storage battery locomotives, for the same service have been standardized up to and including 6 tons. Sleeve type armature bearings of bronze continue to give such good results that the extensive application of anti-friction bearings is still unjustifiable. Flexible gears have been adopted by large operating companies and wide application of this type of gearing is expected. Oil bearings have been introduced on large locomotives for armature bearings, and give promise of very satisfactory results.

Control.

In the matter of control several notable improvements have been made. There have been numerous applications of the pneumatically operated drum type control. The equipments supplied for the New York subway will be supplied with automatic train line couplers operating automatic storage battery control circuits, which are at a potential of 32 volts above the ground. The further development of the multiple unit control permitting any number of cars in a train to operate in unison makes possible a schedule performance which even the largest of steam locomotives would be incapable of maintaining. In the control of electric locomotives plans for the incorporation of regenerative braking will be an innovation for this country. Due to the interpole it is now possible to control the speed of trains by changing the field strength.

Overhead Construction.

Overhead line construction has been developed in many respects and the problem of current collection has received a great deal of study. As a device for collecting current the ordinary trolley wheel has proven successful for handling far heavier equipment than originally contemplated. The roller pantagraph which is in effect an elongated trolley wheel has proven very successful for service for which the ordinary trolley wheel would not be suitable. The sliding pantagraphs fitted with copper faces have a collecting capacity in excess of the roller.

An improvement in overhead catenary construction has accomplished the double purpose of securing greater flexibility and an increased conductivity by the use of two conductors lying close together in the same horizontal plane with the hangers located alternately so that the mid-span of each conductor is opposite the hanger on the other. By means of such an equipment it is now possible to collect 2,000 amperes while running at a speed of 60 miles per hour.

Electric Operation of the B. A. & P. Ry.

J. B. Cox

Actual results as indicated by the first six months of full electrical operation of the B. A. & P. show the total net saving in operating expenses to be at the rate of $242,299.12 *per year or an earning of* 20.02 *per cent on the investment, of which the decrease in the cost of coal and power is* 12.5 *per cent.*

During this time the average tons per train hauled by the electric locomotives has increased 33 *per cent, the average time per trip decreased* 30 *per cent, the delays to traffic decreased* 41 *per cent, the number of trains decreased* 25 *per cent and the number of engine and train crews decreased* 25 *per cent.*

The Butte, Anaconda & Pacific Railway, which has already been described at some length in the March and August numbers of the RAILWAY ELECTRICAL ENGINEER, was built in 1892 principally for the purpose of conveying the ore from the mines at Butte to the Washoe smelter which has been located at Anaconda, 26 miles west of Butte, where an abundant supply of water, so necessary in the reduction of the ore, was obtainable. The tracks connecting Butte and Anaconda constitute the main line, which is approximately 25.7 miles in length. As the mines are mostly around the top of Butte Hill and the shafts through which the ore is hoisted to the surface are scattered over a considerable area, yards were built at a convenient point on Butte Hill for the concentration of the cars containing the ore from these shafts, as well as to serve as a distribution point for the supplies to the mines, and a branch locally known as the Missoula Gulch line, was built from these yards to connect with the main line at Rocker, where yards were also established.

Since the concentrator at the smelter is also on a hill, at an elevation of approximately 340 ft. above the main line, it was advisable to establish another yard at East Anaconda from which to distribute the ore and other supplies to the different centers on Smelter Hill. The lines from these yards at East Anaconda to the smelter are known as the Smelter Hill lines, the longest branch of which is that leading to the concentrator, which is about 7¼ miles in length.

From the Butte Hill yards spur tracks radiate about Butte Hill to the shafts of the various mines and other points where supplies are to be delivered. Bins for receiving ore as it is hoisted from the mines are located near each shaft and from these bins the ore is loaded into hopper-bottom steel ore cars of 50 tons capacity each, these loaded cars being delivered to the Butte Hill yards, where they are made up into trains and taken down to the Rocker yards, where they are made up into still larger trains and taken over the main line to East Anaconda yards. Here the trains are broken up to be transported in smaller units up Smelter Hill to the concentrator yards. Thus practically all of the ore cars are handled by five different engine crews between the ore bins at the mines and the receiving bins at the concentrator.

A total of 27 steam locomotives was owned by the railway company, classified as follows: Switching, 7; consolidation, 8; mastodon, 10; passenger, 2.

The coal used on the steam locomotives was obtained from the mines at Diamondville, Wyoming, and had to be transported approximately 395 miles for delivery to the bins of the railway company, at which point its average cost was approximately $4.25 per ton.

Electrification of Mine Machinery Suggested General Electrification.

The machinery at the mines and the smelter had mostly been electrified, and the results had been so satisfactory that the railway company had a study of their conditions made for the purpose of investigating the advantages that might be expected from the electrification of their lines, the result of which was the placing of a contract in December, 1911, for the electrical equipment of the main portion of its line, consisting of the main line, spurs and yards between Butte and Anaconda, the Missoula Gulch line between Rocker and Butte Hill yards and the Smelter Hill lines. Owing to local conditions on the spur tracks leading to the various mines from Butte Hill yards, it was thought advisable not to electrify these until a later date. The tracks recommended to be electrified totaled approximately 90.5 miles, all of which are supplied with power from two substations.

Hydroelectric Stations.

The Anaconda substation is connected with the Butte substation by three high-tension trunk lines. The Butte substation receives power over five separate transmission lines from six hydroelectric stations of the following rated capacities:

Big Hole Development........	3,000 kw.	60 ft. head.
Madison River Development....	9,000 "	110 " "
Canyon Ferry Development....	7,500 "	35 " "
Hauser Lake Development.....	14,000 "	60 " "
Black Eagle Development......	3,000 "	44 " "
Rainbow Development	21,000 "	110 " "
Total..........	57,000 "	

There is also now under construction the Great Falls Development, 60,000 kw., 155-ft. head.

Seventeen 80-ton electric locomotive units were purchased, originally, fifteen of which are being operated in freight service and two in the passenger service.

These units are of the articulated, double-truck type with twin gears mounted on projections provided on the wheel centers for the purpose, and in general mechanical design are similar to the electric locomotives in operation on the Great Northern railway, the Detroit River Tunnel railway and the Baltimore & Ohio railway.

Operations Began in 1913.

Work on the electrification began in the spring of 1912, and the first electric locomotive was run in Anaconda on May 14th, 1913, about a year later. On May 27, two ore trains were hauled up Smelter Hill on trial trips with electric locomotives and on the following day a double-unit electric locomotive took over the regular day service of hauling the ore from East Anaconda yards to the concentrator yards, the distance between which is approximately seven miles, the ruling gradient being 1.1 per cent compensated, and the grade fairly uniform through the entire distance. The steam locomotives used in this service were of the Mastodon type, weighing 108 tons, 83 tons of which was on the drivers. The total weight of locomotive and tender was about 163 tons, which would average closely to the weight of the double-unit electric locomotive superseding it. The steam locomotive made ordinarily six round trips per shift, hauling 16 loaded ore cars per trip, equaling 96 cars per shift.

---

*Abstract of paper presented before the Pacific coast section of the A. I. E. E.

The average time for the trip from East Anaconda to the concentrator yards with 16 loaded cars for the steam locomotive was about 45 minutes. The double-unit electric locomotive began taking only 16 cars per trip but made 8 trips per shift, delivering 128 cars per shift. The average time for the up-hill trip with the electric locomotive was about 22 minutes or approximately half the time required by the steam locomotive for the same number of cars. Empty cars were taken to East Anaconda on the return trip which, being all down grade, gave the electric locomotive no decided advantage, as the speed in either case was limited to about 25 mi. per hr. for safety, on account of the curves in the line. The number of cars hauled per trip was kept the same with the electric locomotives in the beginning as it had been with steam, as it had been decided to make the change-over by gradually replacing one steam locomotive at a time with an electric, taking the engine crew off the one and placing it on the other, thus breaking them in on the electric locomotives in regular service.

Regular Steam Engineers Used.

One of the regular steam engineers had been given special instructions on the electric locomotives during the experimental running in order that he might become competent to act as instructor to the other engineers until they were sufficiently familiar with the electric locomotives to be left alone.

The load per trip in this service was gradually increased from 16 cars to 25 cars which is to be the standard for the present. The average time for the up-hill trip with 25 cars is about 26 minutes so that eight trips per shift is easily made, making a delivery of 200 cars possible or an increase of slightly more than 108 per cent over what had been possible for the same crew with steam locomotives. These loaded ore cars average from 70 to 72 tons each, making the trailing load for a 25 car train from 1,750 to 1,800 tons.

On arrival at the concentrator yards the ore trains are taken by a switching engine called the "spotter," which places one car at a time over the weighing scales, after which they are rearranged for placement over the concentrator bins from which the ore is fed by gravity to the crushers.

Electric Locomotives Gradually Replace Steam.

On June 20th this spotting service was taken over by a single-unit electric locomotive and on July 2nd the night service up Smelter Hill was taken over by the double-unit electric locomotive. The steam locomotive used for the spotting service was of the consolidation type and weighed 93 tons, 83 of which was on drivers, the tender weighing loaded 62 tons making the total weight of engine and tender 155 tons. Thus where formerly during steam operation four engine and train crews had been required, now with electric locomotives three similar crews were able to do the same work and in less time, thereby reducing the number of crews required in this particular service 25 per cent.

On October 1st the regular passenger service between Butte and Anaconda was taken over for electrical operation. The steam locomotives used in the passenger service weigh approximately 80 tons, 60 tons of which were on drivers, the tender loaded weighing 52 tons, making the total weight of engine and tender 132 tons. The distance between the stations—Anaconda to Butte—is 25.7 miles, the schedule time for the trip, one hour. No change has been made in this time though a reduction of 20 per cent would be possible with the electric locomotives were such desired. The standard passenger train consists of one mail and baggage coach and two to four passenger coaches, but as many as 12 passenger coaches are handled by a single electric unit on special occasions, such as excursions and on holidays. It may be of interest to note here that on the day shift, averaging four trips per day, during the first five months the passenger train did not come in late a single time on account of engine trouble.

On October 10th a double-unit electric locomotive was put in the day freight service on the main line between East Anaconda and Rocker, a distance of 20.1 miles. The steam locomotive replaced in this instance was of the Mastodon type weighing 103 tons, 77 tons of which was on drivers, making the total weight of locomotive with tender 158 tons. The standard train hauled on the trip west was 50 to 55 loaded ore cars weighing approximately 3,500 to 4,000 tons gross and the average running time of such trains where no stops were made was about 1½ hours, corresponding to an average speed of approximately 13.4 miles per hour. In the beginning the electric locomotive took only the standard train but made the trip without stop in about one hour, corresponding to an average speed of 20 mi. per hr. The ruling gradient on the westward trip is 0.3 per cent and about half the distance is down grade. On the 0.3 per cent grade with a 55-car train, the steam locomotive made about seven mi. per hr. The electric locomotives with similar train now make about 16 mi. per hr. on the same grade.

Train Load Increased.

The weight of the trains hauled by the electric locomotives on this run has been gradually increased up to 65 loaded ore cars averaging about 71 tons each, making the gross weight trailing about 4,620 tons. Adding 160 tons for the weight of the double-unit electric locomotives and 20 tons for the caboose makes a gross train weight of approximately 4,800 tons.

The remainder of this main line freight service was gradually taken on during the months of October and November, thus completing the electrification of the main line service. As many as 76 ordinary freight cars loaded with coal, coke and general merchandise have been taken in a single train on the west-bound trip and 85 empties are frequently taken from East Anaconda to Rocker east-bound, the ruling grade being 1 per cent.

June, 1913, Shows Large Gains.

Comparative results of the month of June, 1913, steam operation vs. the same month, 1914, electrical operation of this main line service, shows that with a slight increase in the total tons of ore hauled the average tons per train was increased from 1,761 to 2,378 or 35 per cent, thus decreasing the average number of trains per day from 12.5 to 9.3, or 25.6 per cent.

The average time per trip during steam operation was approximately two hours and 25 minutes, while with the electric locomotive it was approximately one hour and 45 minutes, showing a decrease of 40 minutes, or 27.5 per cent. These figures represent the time put in by the crews between Rocker and Anaconda, the distance being 21.8 miles.

The result of these improvements shows that the overtime in this particular service has been decreased 73.5 per cent and the total time 42 per cent, resulting not only in greater economy to the railway company but in shorter and easier hours for the crews.

The service on the Missoula Gulch line running between Rocker and Butte Hill yards was taken over for electrical operation on October 20th. This line is 4.5 miles in length and the ruling gradient 2.5 per cent. The steam locomotives used on this line were of the Mastodon type, weight 106 tons, 87 tons of which were on the drivers, the tender loaded weighing 56 tons, thus making the total weight of engine and tender 162 tons. Two complete crews had been required to handle this service during steam operation, averaging six trips per day each. A single crew with a double-unit electric locomotive has been doing this work successfully. Thirty-five to 45 loaded ore cars are taken down from Butte Hill yard to Rocker, and about an equal number of empties taken up. In addition to the empties, large quantities of timber and supplies for the mines are delivered over this line.

On November 25th, the last of the electric locomotive units went into service, thus completing the electrification originally intended.

No Difficulty from High Voltage.

This was the first installation of 2,400-volt direct-current apparatus for the operation of a railway in this country, 1,500 volts, being the highest heretofore installed for such a purpose.

Difficulties especially attributable to the higher potential have been negligible, and while there have been occasional instances of arcing and flashing or short circuits due to ordinary causes, the resultant damages have been really smaller than might be expected from a like occurrence on a 600-volt installation of equal capacity.

Large Savings Shown.

The saving from the partial substitution of electric power for coal is the chief item, being at the rate of $150,727.04 per year, which is remarkable when it is considered that more than 39 per cent of the total combined costs for fuel and power for the period considered was for coal and charged against electrical operation. In this instance the saving on this item alone would undoubtedly justify the expenditure covering the entire cost of electrification.

The total saving from locomotive performance alone is at the rate of $237,581.82 per year, to which should be added the credit of handling an increase of traffic at the rate of 13,938,136 ton-miles per year or 8.77 per cent more than was handled by the steam locomotives during the period compared. To this saving from locomotive performance should be added the saving from trainmen's wages, which is at the rate of $31,146.30 per year, or a decrease of approximately 21 per cent, due largely to the elimination of overtime, making the total saving from these two items $268,728.12 per year. From this should be deducted $10,839.12 for maintenance of the distribution system, leaving $257,889 as the net operating saving per year due to electrical operation.

The roadmaster states that it is quite evident that the electric locomotives are much easier on the track at curves but that there is no noticeable difference on tangent track, and that while sufficient time has not yet elapsed to form definite conclusions, present indications lead him to expect that any difference relative to his work will be favorable to the electric locomotives.

Arranging the items of expense in the order of usual appearance in the summary of a standard locomotive performance sheet, and placing them on a yearly basis, results as follows:

Item of operating expenses	Steam, 1913	Electric, 1914	Decrease, 1914	Per ct. dec.
Fuel and power	$315,235.74	$164,508.70	$150,727.04	47.81
Repairs	124,787.90	92,278.08	32,509.82	26.05
Enginemen's wages	104,461.18	71,225.88	33,335.30	31.81
Enginehouse expenses	29,907.80	18,638.38	11,269.42	37.68
Water	4,953.66	1,193.70	3,759.96	75.90
Lubricants	9,751.44	4,942.32	4,809.12	49.30
Other supplies	5,823.52	4,552.36	1,271.16	21.83
Total locomotive performance	$594,921.24	$357,339.42	$237,581.82	39.93
Trainmen's wages	147,632.30	116,486.00	31,146.30	21.10
Grand total	$742,553.54	$473,825.42	$268,728.12	36.19
Ton miles hauled	158,917,720	172,855,856	13,938,136*	8.77*

*Increase.

The total cost of the electrification including a change of signal system on Smelter Hill, the extra motor-generator set recently installed at Anaconda, interest during construction and all incidentals due in any way to the electrification, was in round numbers $1,201,000. This does not include the stepdown transformers, which are the property of the power company, but on the other hand no deduction has been made for the salvage due to the elimination of 20 steam locomotives.

Penn. R. R. Tests Storage Battery Car

An Edison storage battery car met all requirements in a test run made on Nov. 16 over the main line of the Pennsylvania Railroad from Newark to Holmesburg, near Philadelphia. The car used on this trip had been ordered by the Lorain, Ashland & Southern from the Railway Storage Battery Car Company, and was on its way to be delivered to the railway company when this test was made. This is the second battery car equipment for this line. On this test run representatives of the Pennsylvania and several other railroads made the trip.

This is the schedule of the trial run:

	Miles
Leave Newark 11:45 a. m.	0
Arrive Trenton 1:24 p. m.	48.1
Leave Trenton 1:31 p. m.	—
Arrive Bristol 1:54 p. m.	58.1
Leave Bristol 1:55 p. m.	—
Arrive Holmesburg Junction 2:24 p. m.	68.3

Two hours and 31 minutes was the actual running time of this 68-mile trip, excluding stops at Trenton and Bristol to let off passengers. The average running speed of the car, 27 m.p.h., and maximum speed of 36 m.p.h. was very creditable in view of the fact that forty-four passengers were on board, and, especially owing to the short-circuiting of one of the motors while charging in the Newark yard, so that the run was made with only three 20-h.p. motors in service.

The overall length of the demonstration car was 48 ft. 9½ in., and was composed of a passenger compartment, a 14 ft. 5¼ in. smoking compartment. Power at about 440 volts was supplied by 240 Edison A-12-H storage battery cells. The total weight of the car was 31 tons.

This car will be operated temporarily for about thirty days on the 4-mile Holmesburg Junction-Bustleton branch of the Pennsylvania Railroad, and thereafter two new storage battery cars, operated separately, will probably be introduced for the regular passenger service of the branch line. These two cars will be either suburban passenger cars of the Pennsylvania Railroad re-equipped with storage batteries, motors and controller or standard 50-ft. double-truck Edison storage battery cars of the Railway Storage Battery Car Company with 32-ft. passenger and 12-ft. 10-in. baggage compartments. They will operate for about 130 miles each day on one battery charge and will be designed for maximum speeds of 30 to 35 m.p.h. At the end of about six months, if the operation of this equipment proves satisfactory in reliability and saving of car-mile costs, from fifty to seventy-five storage battery cars may be adopted for general branch line service on this steam railroad.

Purchase of Power for New Haven Electrification

The New York, New Haven & Hartford R. R. has recently closed a long term contract with the United Electric Light & Power Co., of New York, for supplying energy to assist the railroad company's generating station at Coss Cob, Conn., in operating the electrified station from New York to New Haven.

Five double "T" connected transformer tanks will be used eventually, but only three of these are being installed at present. They will receive three phase, 25 cycle energy at 24,600 volts, which will be stepped down to 11,500 volts from the conductor to ground. Two 20,000 k. w. 6,600 volt, 25 cycle, three phase Westinghouse turbo generators will be added to the 201st Street generating station of the U. E. L. & P. Co., to take care of the increased load. It is expected that about 50,000,000 k. w. hour of energy will be supplied per year.

C. M. & St. P. Ry. Electrification

Some Additional Notes on Power Supply and Conditions Encountered

In the December issue of the Railway Electrical Engineer we endeavored to describe the equipment to be used on the proposed electrification of the C., M. & St. P. R. R. In the following article we shall describe the nature of the country through which the road passes and the sources of power.

The first step taken towards electrification by the Chicago, Milwaukee and St. Paul Railway was to enter into a contract with the Montana Power Company for an adequate supply of power over the 440 miles of main line considered for immediate electrification. The precautions taken both by the railway company and power company to safeguard the continuity of power supply should guarantee a reliable source of power subject to few interruptions of a momentary nature only.

The Montana Power Company covers a great part of Montana and part of Idaho with its network of transmission lines, which are fed from a number of sources of which the principal ones are tabulated below:

Great Falls, Montana, on the Missouri River, at the Site of the New 60,000-k.w. Hydroelectric Development.

Madison River	11,000 kw.
Canyon Ferry	7,500 kw.
Hauser Lake	14,000 kw.
Big Hole	3,000 kw.
Butte, steam turbine	5,000 kw.
Rainbow Falls	21,000 kw.
Small powers aggregating	7,390 kw.
Total Power developed	68,890 kw.

Further developments, part of which are under construction, are as follows:

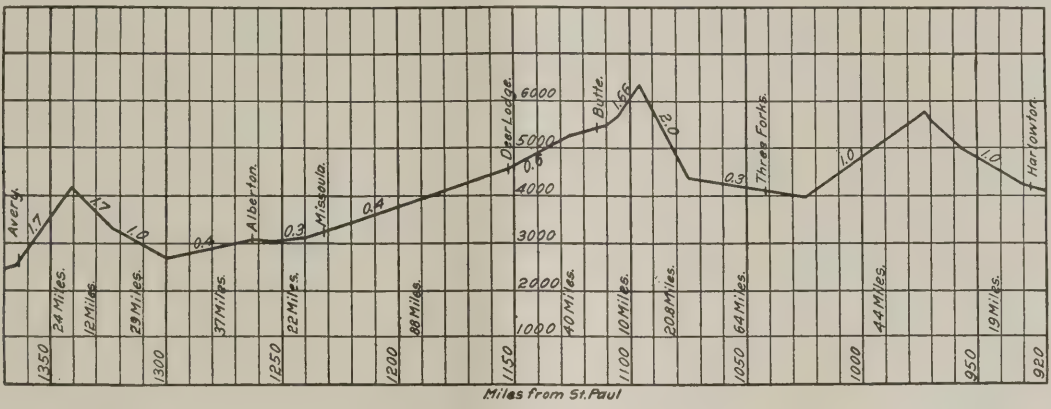
Great Falls	85,000 kw.
Holter	30,000 kw.
Thompson Falls	30,000 kw.
Snake River	20,000 kw.
Missoula River	10,000 kw.
Total	175,000 kw.

Ore Train on the Electrified B. A. & P. at Silver Bow.

Total power capacity developed and undeveloped—244,000 kw.

The several power sites are interconnected by transmission lines, supported on wooden poles and operating at 50,000 volts for the earlier installations, and on steel towers and operating at 100,000 volts for later installations. Ample water storage capacity is provided in the Hebgen Reservoir of 300,000 acre-feet, supplemented by an auxilary reservoir capacity at the several power sites, which brings the total up to 418,000 acre-feet. The Hebgen Reservoir is so located at the head waters of the Madison River that water drawn from it can supply in turn the several installations on the Madison and Missouri Rivers, so that the same storage capacity is used a number of times, affording an available storage capacity considerably greater than is indicated by the figures given. It would seem, therefore, in changing from coal to electricity as a source of motive power, that the railroad is amply protected in respect to the reliability and continuity of the power supply.

Due to the great facilities available and the low cost of construction under the favorable conditions existing, the railway company will purchase power at a contract rate of $0.00536 per kilowatt-hour based on a 60 per cent load factor. It is expected under these conditions that the cost of power for locomotives will be considerably less than is now expended for coal. The contract between the railway and power companies provides that the total electrification between Harlowton and Avery, comprising four engine divisions, will be in operation January 1st, 1918.



Profile of C., M. & St. P. Ry from Avery, Idaho, to Harlowtown, Mont.

In order to connect the substations with the several feeding-in points of the Montana Power transmission lines, a tie-in transmission line is being built by the railway company that will permit feeding each substation from two directions and from two or more sources of power. This transmission line will be constructed with wooden poles, suspension type insulators, will operate at 100,000 volts and will follow, in general, the right of way of the railway company except where advantage can be taken of a shorter route over public domain to avoid the necessarily circuitous line of the railway in the mountain districts.

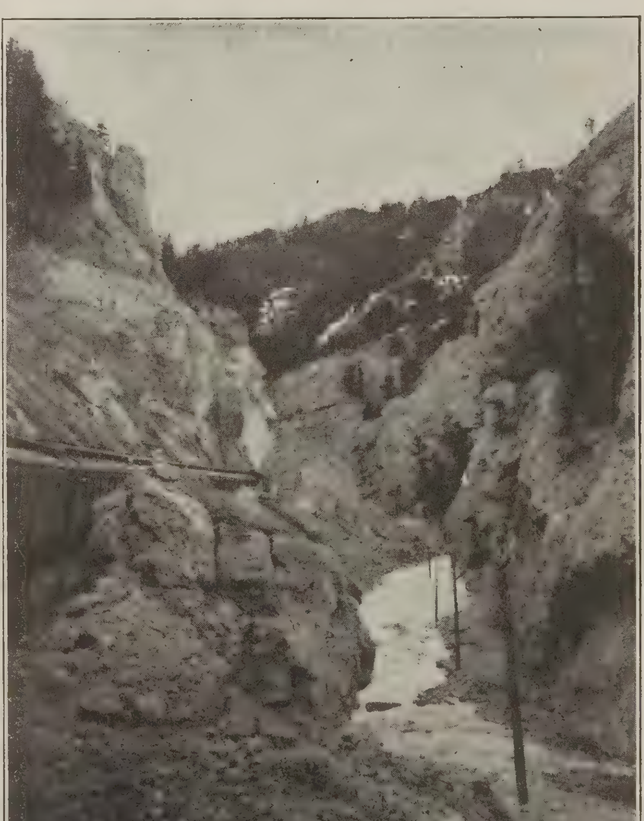
The C. M. & St. P. Ry. Passes Through Mountainous Country Which is Heavily Snowbound in Winter.

As described elsewhere in this issue of the Railway Electrical Engineer, the 2400 volt direct current installation of the Butte, Anaconda & Pacific Railway in the immediate territory of the proposed Chicago, Milwaukee & St. Paul electrification has furnished an excellent demonstration of high voltage direct current locomotive operation during the past year and a half, and the selection of 3000 volts direct current for the Chicago, Milwaukee & St. Paul was due in a large measure to the entirely satisfactory performance of the Butte, Anaconda & Pacific installation.

The equipment for this road was also furnished by the General Electric Company, and a comparison based on six months' steam and electric operation shows a total net saving of more than 20 per cent on the investment or total cost of the electrification. These figures, of course, do not take into account the increased capacity of the lines, improvement to the service and the more regular working hours for the crews. The comparison also shows that the tonnage per train has been increased by 35 per cent, while the number of trains has been decreased by 25 per cent, with a saving of 27 per cent in the time required per trip.

Location of Substations.

The substation sites of the Chicago, Milwaukee & St. Paul electrified zone provide for an average intervening distance of approximately 35 miles, notwithstanding that the first installation embraces 20.8 miles of 2 per cent grade westbound and 10.4 miles of 1.66 per cent grade eastbound over the main range of the Rocky Mountains. With this extreme distance between substations and con-



Section of the Railroad Winding Around Rugged Peaks Through the Famous 16 Mile Canyon.

sidering the heavy traffic and small amount of feeder copper to be installed, it becomes apparent that such a high potential as 3000 volts direct current permits of a minimum investment in substation apparatus and considerable latitude as to location sites.

The location and equipment of the several substations is as follows:

Station	Miles from Deer lodge	No. of Units	Kw. per Unit	Total
Morel	17.1	2	2000	4000
Janey	50.5	3	1500	4500
Piedmont	77.9	3	1500	4500
Eustis	120.6	2	2000	4000

The Chicago, Milwaukee & St. Paul Railway, from Harlowton to the coast, crosses four mountain ranges. The Belt Mountains at an elevation of 5768 ft., the Rocky Mountains at an elevation of 6350 ft., the Bitter Root Mountains at an elevation of 4200 ft. and the Cascade Mountains at an elevation of 3010 ft. As stated in December, the first electrification between Three Forks and Deer Lodge, calls for locomotive operation over 20.8 miles of 2 per cent grade between Piedmont and Donald at the crest of the main Rocky Mountain Divide, so that the locomotives will be fully tested out as to their capacity and general service performance in overcoming the natural obstacles of the first engine division.

Track provision is being made at Donald, the summit of the grade, to enable the pusher locomotive to run around the train and be coupled to the head end to permit electric braking on the down grade. In this case, the entire train will be under compression and held back by the two locomotives at this head end, the entire electric braking of the two locomotives being under the control of the motorman in the operating cab of the leading locomotive. It is considered that electric braking will prove very valuable in this mountain railroading; for, in addition to providing the greatest safety in operation, it also returns a considerable amount of energy to the substations and transmission system, which can be utilized by other trains demanding power. In this connection, the electric locomotives will have electric braking capacity sufficient to hold back the entire train on down grade, leaving the air brake equipment with which they are also equipped to be used only in emergency and when stopping the train. There is, therefore, provided a duplicate braking system on down grades, which should be reflected in the greatest safety of operation afforded and the elimination of a considerable part of break-downs, wheel and track wear and overheating with consequent reduction in maintenance and improvement in track conditions.

With the completion of the remaining engine divisions, it is proposed to take advantage of the possibilities afforded by the introduction of the electric locomotive by combining the present four steam engine divisions into two locomotive divisions of approximately 220 miles length, changing crews, however, at the present division points. As the electric locomotive needs inspection only after a run of approximately 2000 miles, requires no stops for taking on coal or water, or layover due to dumping ashes, cleaning boilers or petty roundhouse repairs, it is expected that the greater flexibility of the locomotive so provided will result in considerable change in the method of handling trains now limited by the restrictions of the steam engine.

The Graphic Ampere Hour Meter

in Car Lighting Service

Various tests have been made from time to time on axle generator car lighting systems using recording volt meters and ammeters. These have shown up some very interesting information regarding the operation of the equipment, particularly in regard to the operation of the lamp voltage and generator regulators, and not infrequently have given direct evidence of all night poker games, etc., standing in the coach yards. In order to get any definite and reliable information as to the treatment which the storage battery receives, however, it is necessary to employ a meter which makes a cumulative record of the total battery input and output in ampere hours—in other words, a graphic ampere hour meter. Such an instrument was built experimentally about a year ago at the suggestion and request of Mr. Ernest Lunn, chief electrician of the Pullman Company, and has been used for test purposes on various occasions. Recently, however, the meter has been produced on a commercial basis by the Sangamo Electric Company, at Springfield, Ill.

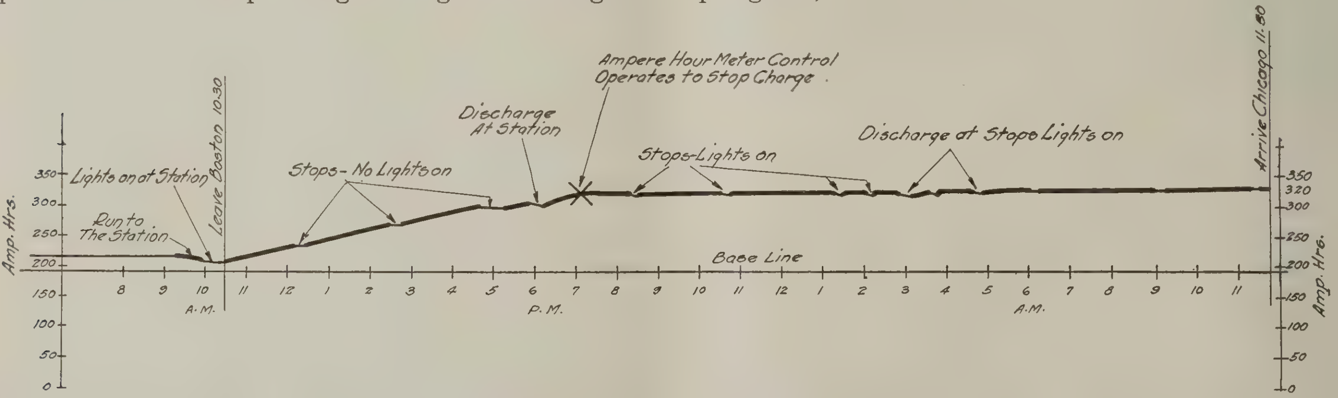


Fig. 1. Graphic Ampere Hour Meter Chart Showing Proper Operation of Equipment Running Between Boston and Chicago. Heavy Section of Curve is Caused by Vibration Due to Moving Train. Light Sections of Line Indicate Stops.

Operation of the Meter.

The meter consists of a standard ampere hour meter of the variable resistor type, as described in the Railway Electrical Engineer of March, 1914. It will be recalled that this meter records both charge and discharge, moving in a clockwise direction on charge and in the reverse direction on discharge. By means of a variable resistor element the meter automatically runs slower on charge than on discharge by any desired percentage and thereby automatically compensates for battery losses and provides for a suitable amount of overcharge. The dial hand then at all times indicates the amount of discharge which has been taken from the battery in true ampere hours, and when the hand gets back to zero the previous discharge plus 25 per cent (or any other desired value) has been put back into the battery.

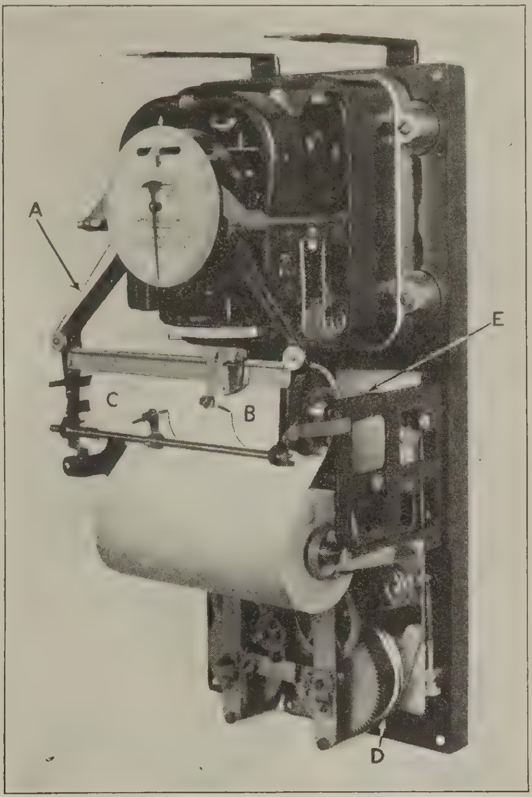


Fig. 2. Graphic Ampere Hour Meter with Case Removed Showing Recording Pencil (B) Mounted on Rolling Carriage Moved Horizontally by Ampere Hour Meter Gear Train.

In the regular ampere hour meters the hand makes a contact at the zero point which stops further charging. In the graphic meter this zero contact, of course, is removed as this meter is simply for the purpose of recording operating conditions as they exist.

In the graphic ampere hour meter a sheave is mounted on the main shaft of the dial hand immediately back of the dial and the small German silver chain "A" (Fig. 2), makes several turns around this sheave and is permanently connected to it. As the main dial hand of the meter slowly revolves, its motion is transmitted by means of the chain to the recording pencil "B." This is mounted on a rolling carriage and moves with very little friction on a metal track which serves also as a guide for the carriage. The sheave mounted on the main shaft of the meter is so designed as to give a horizontal movement of the carriage of $\frac{1}{16}$ of an inch for every 10 ampere hours indicated on the meter dial. A movement of the carriage pencil "B" of $\frac{1}{16}$ of an in. in a discharge direction would then represent 10 ampere hours discharge, while a movement of the carriage in the opposite, or charging direction, of $\frac{1}{16}$ of an in. would represent 25% more than this (if the resistor element is set at this value), or 12½ ampere hours. It might occur to some that this movable carriage for the recording pencil would add sufficient friction to cause the meter to record inaccurately; mercury meters of this type, however, have a very high torque which acting through the reduction gear gives a torque on the main dial shaft of 3 ft. lbs. This would theoretically require a friction of 75 lbs. to stop the pencil carriage.

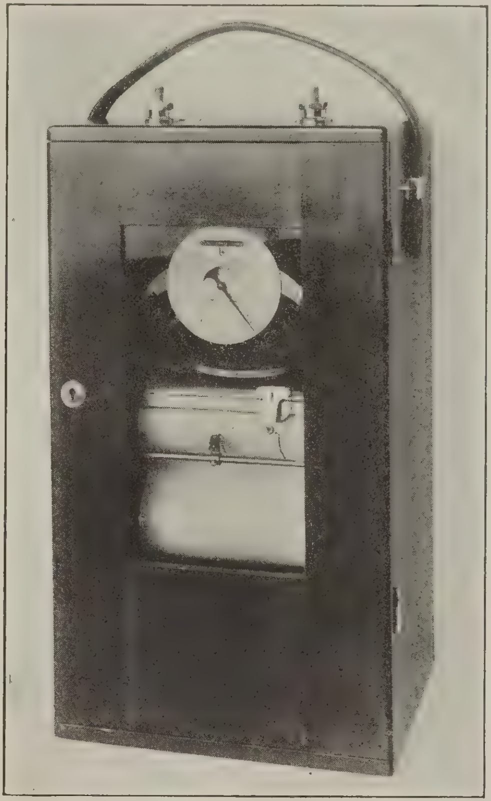


Fig. 3. Graphic Ampere Hour Meter Mounted in its Carrying Case.

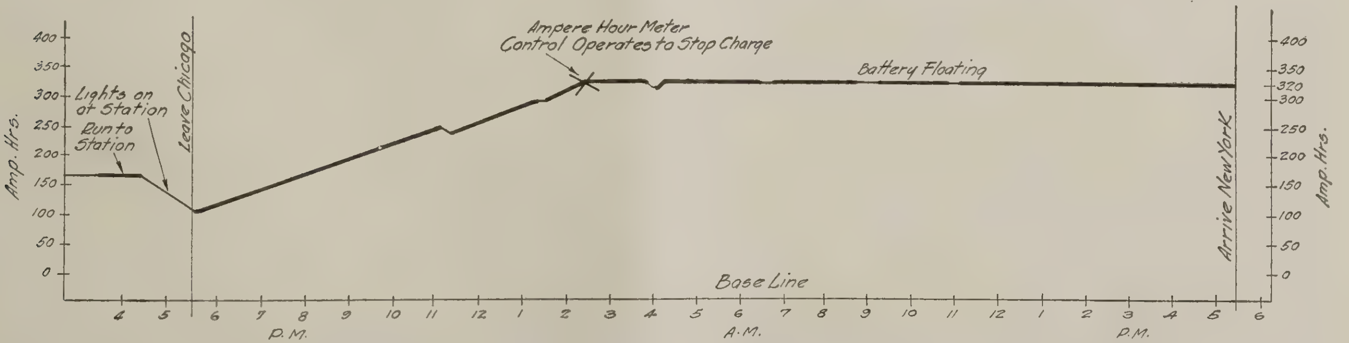


Fig. 4. Another Graphic Ampere Hour Meter Record Showing Proper Operation of the Equipment on Run Between Chicago and New York. Horizontal Section of the Line Indicates Battery Floating at Full Charge.

The pencil is adjustable and is usually sharpened with a flat point so as to give a fine line, and at the same time have long wearing qualities. It is supported from the movable carriage by means of a substantial spring arm, as shown, which provides proper pressure of the pencil on the paper.

The stationary pencil "C" is for the purpose of giving a base line on the record sheet. This may be set at any point desired and an adjustable spring provides proper pressure of the pencil on the paper. This base line, as shown in the accompanying diagrams, has no reference whatever to the zero capacity of the battery. It should always be considered that we are dealing with full batteries, instead of empty ones.

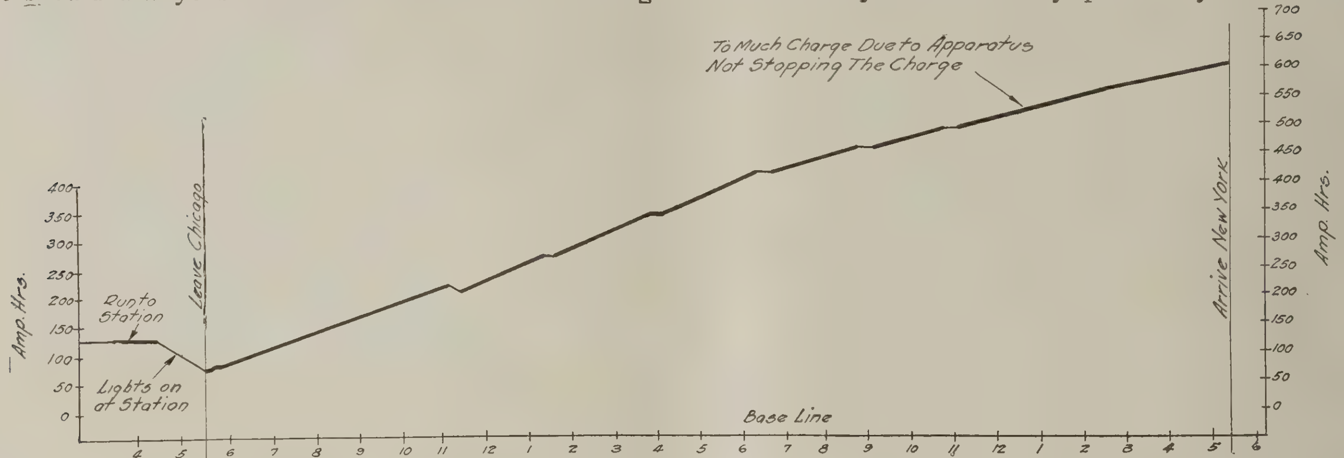


Fig. 5. Graphic Record Showing the Operation of Same Equipment as Fig. 4, but Without Ampere Hour Meter or Voltage Control of Charge.

A substantial 8 day clock movement, as shown at the bottom of the meter, operating through the drum "D" and cord "E," furnishes power which moves the recording paper. The speed of motion is adjusted to approximately ¼ of an in. for every half hour. One foot of record tape will then represent a whole day's run, and a week's run would require only 7 ft. of tape. Every half hour the clock mechanism strikes, and in doing so, causes the base line pencil "C" to move transversely on the paper about ⅛ of an in., giving the marks of time on the base line as shown in the accompanying diagrams. This automatically records the time of operation and by marking on the tape the time of starting the test, the exact time at all points on the curve is obained.

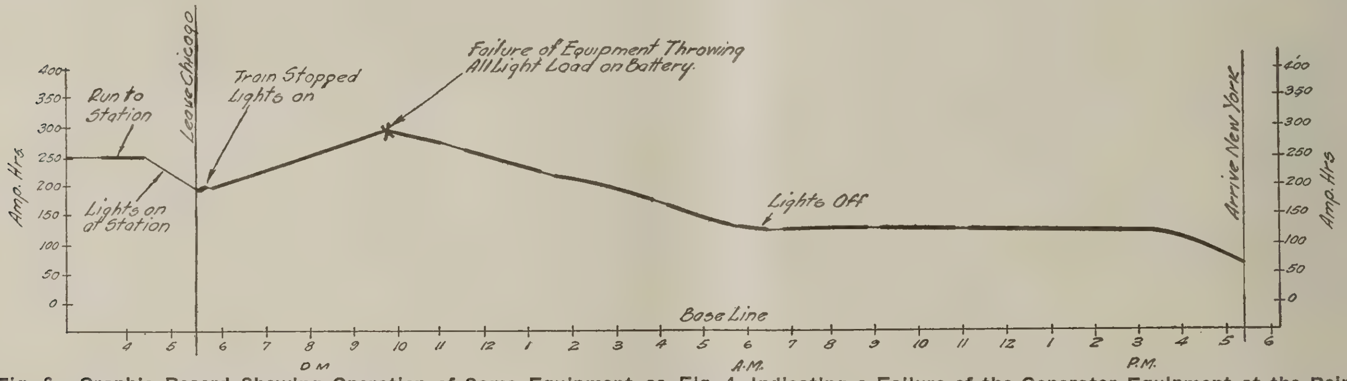


Fig. 6. Graphic Record Showing Operation of Same Equipment as Fig. 4, Indicating a Failure of the Generator Equipment at the Point Marked.

Test Results.

The graphic ampere hour meter gives a definite indication of the treatment which any storage battery receives, both as to current rate and time of charge and discharge and the more important information as to the actual condition of battery charge at any time. This meter should be used occasionally to check the operation of all types of axle car lighting equipments and, since it requires no more attention than to simply install it in circuit and wind the clock once a week, it will no doubt be found a very useful and practical instrument in car lighting service.

The accompanying curve, Fig. 3, shows the record of battery charge and discharge on a car running between Boston and Chicago. It will be noted that when the car is not in motion the graph of the recording pencil is light, but as soon as the car begins to move, whether the equipment is generating or not, the line becomes heavy. In this way practically all of the stops are indicated.

As mentioned above, the base line has no reference whatever to the battery capacity scale, but simply gives a base line from which values of charge and discharge can be measured. For the sake of illustration, we have assumed in the curve, Fig. 1, that the capacity of the battery when fully charged, as it was from 7 p. m. to the end of the run, is 320 ampere hours. Since $\frac{1}{16}$ of an inch equals 10 ampere hours the vertical scale can easily be figured and we have placed this scale at each end of the curve. The curve as recorded by the meter, however, is simply the two lines shown heavy. In making the zinc etching the curve has been reduced to about half size.

Fig. 1 shows that while standing in the yard there was a capacity of 215 ampere hours in the battery. The run to the station is shown by the heavy horizontal line and discharge now begins as shown by the downward curve of the line. Altogether enroute to and at the station the battery discharged 10 ampere hours. As soon as the train left the station the battery started to charge and this is indicated by an upward slope of the line; since this equipment was set for constant battery current regulation, the upward slope of this line is always at the same angle. If this had been a constant generator current regulator this degree of slope would have varied, depending upon the charging current rate.

It will be noted that at the stops during the day there was no discharge and the light lines, indicating stops, are horizontal. After sunset, however, it will be noted the light lines at all stops slope downward, this indicating a discharge at each stop. As soon as the equipment begins to generate again, however, the curve again begins its upward slope, indicating that the battery is charging at the constant rate of the regulator setting. It will be noted that at 7 p. m., indicated by a cross on the curve, Fig. 1, the battery has reached a full state of charge, and since this equipment was controlled by an ampere hour meter of the variable resistor type, this meter, like the graphic meter, indicated a zero discharge and thereupon closed its zero contact which stopped further charging of the battery. The battery then simply floated on the line, the generator carrying the load of whatever lamps happened to be in use at the time. It will be noted that there are various stops where a slight discharge occurred, but this was quickly replaced by normal operation of the equipment and the controlling meter again operated to stop further charge when the discharge plus 25% had been put back into the battery.

Test Results Showing Normal and Abnormal Conditions.

Fig. 4 is another curve which shows the operation of an axle generator car lighting system with the generator regulator adjusted so as to provide constant battery current; the charge given the battery is controlled by an ampere hour meter of the variable resistor type. As in Fig. 1, we find a very normal condition of affairs with the battery charging normally enroute, a few short discharges at stops, and finally coming to a state of full charge at 2:30 a. m., when the controlling ampere hour meter operated to stop further charge, and so protect the battery from excessive overcharge.

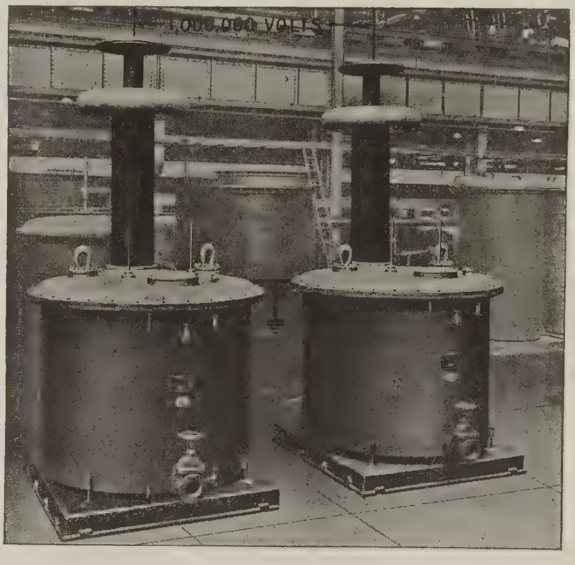
In Fig. 5, however, both the controlling ampere hour meter and the voltage regulating solenoid were purposely cut out of service and the equipment operated as on a simple constant battery current control. This illustrates, of course, only abnormal conditions such as would be experienced in using a regulator of the constant current type without auxiliary control of charge, or when the voltage regulating feature of the combination current-voltage regulators without ampere hour meter control, or when both the ampere hour meter and voltage regulation of equipments with the ampere hour meter control, failed to work. In this run it will be noted that a charge of 525 ampere hours was given a 320 ampere hour battery which at the start showed only a 245 ampere hour discharge. This indicates an overcharge of (280 + 25% or) 350 ampere hours, representing the full normal charging rate for nearly 9 hours on this single run. When considering the effect of such serious overcharging on a battery it is not surprising that the average battery life in car lighting service has been so small in past years before the use of voltage regulators, giving a taper charge, or the controlling ampere hour came into use.

Fig. 6 shows another abnormal condition wherein the equipment failed to generate at the point marked "X" on the curve, due either to lost belt which was not replaced or trouble on the equipment. It will be noted that there is a continual discharge on the battery from this point till the end of the run; this does not follow a straight line, but tapers more to the horizontal as the number of lamps in use is reduced.

At a later date we hope to be able to present some further data giving the results of tests with graphic ampere hour meters, showing the effect of taper charging with the combination current-voltage, and also on the constant voltage types of regulation under various conditions of winter and summer operation. A complete series of graphic ampere hour meter tests under both summer and winter conditions will also demonstrate what is the proper floating voltage for the battery at various times of the year.

Million Volt Testing Transformer

The accompanying illustration shows two testing transformers, having a normal rating of 360,000 volts continuously, and 500,000 volts for short periods. These transformers were recently furnished the Inawashiro Hydro-Electric Power Company of Japan, one to be installed in the generating station on the Nippashi River at the outlet of Lake Inawashiro, about 145 miles from Tokio; the other in the receiving substation at Tokio, where they will be used for testing transmission lines and apparatus in the stations.



Transformers Which Will Develop 1,000,000 Volts.

The design features of interest in these transformers are: the arrangement of the windings to give distributed static fields; the use of condenser terminals to give distributed stresses from terminals to ground; and the terminal "hat" to distribute stresses from terminal tip to ground. The transformers are 19 feet high from base to top of terminal and the tanks are 9 feet high and 9 feet diameter. One high-tension terminal of each transformer is grounded to the core and case, the other being brought out as shown in the illustration. By connecting the cases of the two transformers as shown one million volts can be developed between the two high tension terminals.

These transformers were built by the Westinghouse Electric & Manufacturing Company, and are similar in construction to the 500,000 volt testing transformer previously built by this company.

Carriage Lighting in India

The Indian Railway Board have decided to put electric light in all railway carriages on State work systems, the change being brought about gradually.

This official announcement, of course, means that non-worked systems will have to do the same, and compressed oil gas lighting may regard itself as doomed in India.—*Railway Engineer,* London.

Automatic Battery Charging Current Regulator

Terminal yard charging of storage batteries has been accomplished in the past by two principal methods, namely constant potential charging and series charging. The former method has the advantage of giving a taper charge while the latter prevents excessive current from flowing at the beginning of charge. The disadvantage of the series system is that several batteries in various conditions of charge are connected in series with the result that one battery may be overcharged while another is not brought up to full charge.

In order to retain some of the advantages of both systems an automatic rheostat has been developed and patented by W. H. Sherbondy, who was electrical instructor of the N. W. system of the Pennsylvania lines west. These rheostats may be used in one of two ways, viz., as shown in Fig. 1 for controlling series circuits, or as shown in Fig. 2, for regulating the current in but one circuit. When used as in the first case, the system is essentially a series charging system, but by using the rheostats as in case two, a constant voltage distribution line is used, and the current is controlled at the outlet. In the Chicago yards it is planned to use a one wire feeder and a grounded return, in which case the rails would be bonded to afford a return circuit.

These rheostats are placed in series in the charging circuit and keep the current constant by automatically increasing their resistance as the current tends to increase.

The active resistance elements in these regualtors consist of two carbon piles of the Allen Bradley type, in series. The pressure on these carbon piles is controlled through levers by the expansion of a metal rod, see Fig. 1. The controlling apparatus is made up of a hollow brass rod which is connected to one of conductors to the battery, the other end is plugged with an insulating bushing, through which an iron piston rod projects. This terminates in a laminated brass piston through which the current passes from the piston rod to the enclosing brass rod. Now the end of the brass rod through which the piston rod passes is held mechanically stationary and the other is fastened to the system of levers, which controlls the pressure on the carbon piles. The iron piston rod has comparatively high resistance and the heat radiating from the enclosed portion of it heats the brass tube and causes it to expand and in this way decreases the pressure on the carbon pile. This keeps the current approxi-

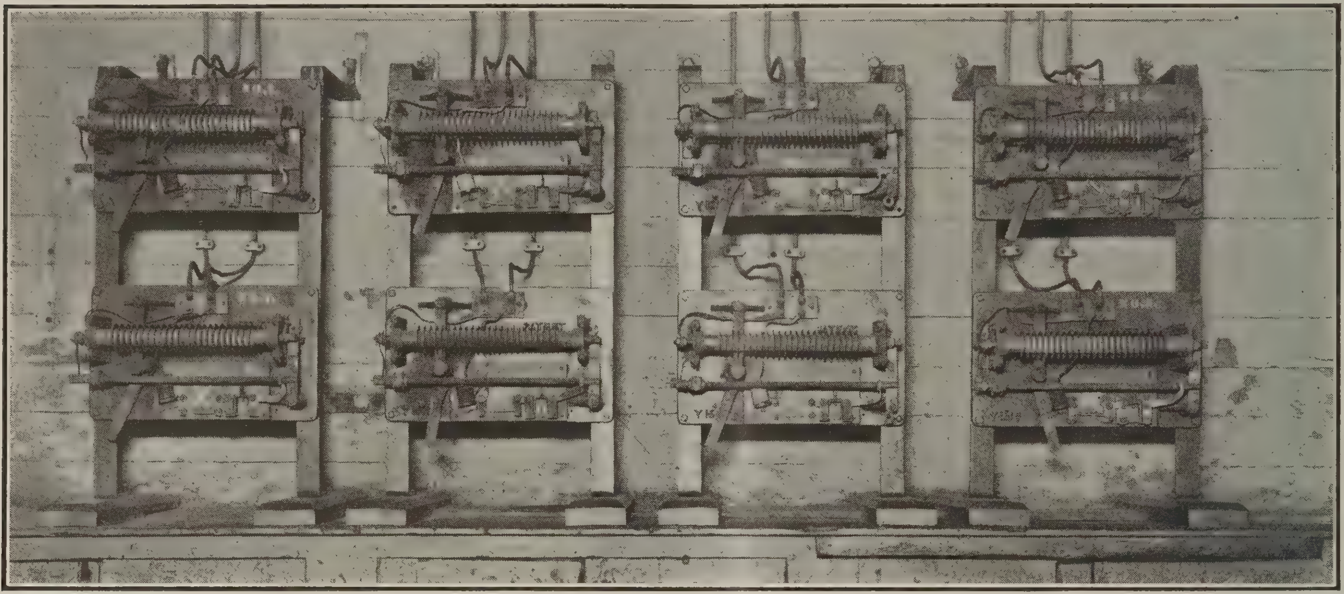


Fig. 1. Automatic Charging Current Regulators Mounted in Battery House. Current is Controlled by Varying Pressure on Carbon Pile Resistance by Means of Expansion of Brass Tube Heated by Iron Wire Carrying Current.

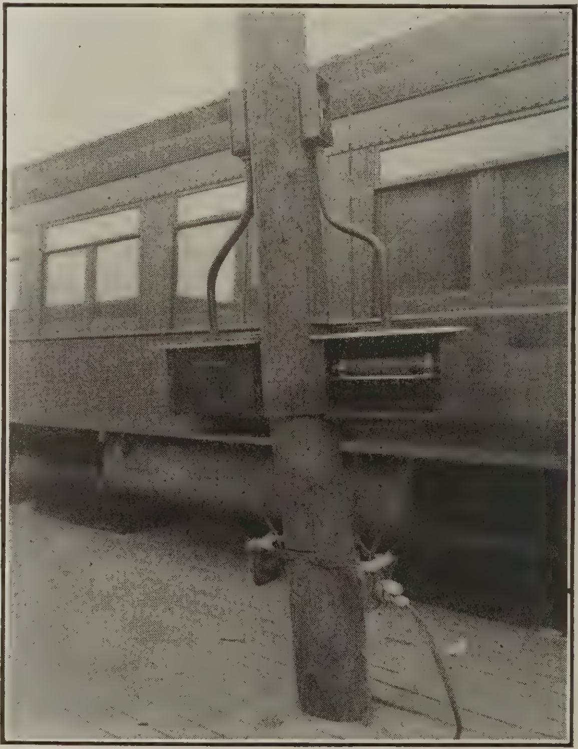


Fig. 2. Two Automatic Charging Current Regulators Mounted on a Pole Near the Charging Outlets for Controlling Charge to Individual Cars.

mately constant, as the instrument is so designed that a small variation in current has considerable effect on the resistance. By adjusting the iron piston rod and piston in and out so that its heating effect is increased or decreased, the current value may be regulated within the limits of the regulator.

These devices are very simple in their construction and with their location in the yards, a battery is put on charge by merely plugging into the charging circuit and it requires no attention during charging. It has even been suggested and plans are on foot to have these regulators put on cars so that the batteries can be charged from the local direct current mains where the voltage is approximately correct.

The Railroad Electricians' Club

Meetings the 3rd Monday of Every Month, 8 P. M.—18th Floor Transportation Bldg., Harrison and Dearborn Sts., Chicago—Everybody Welcome—No Dues

Lead Storage Battery Questions

Pilot Cell Readings.

Prob. 71. Should pilot cell readings be taken of batteries in car lighting service?

Ans. 71. Storage batteries represent such a great investment and one so easily ruined by careless treatment, that every means available should be employed in order to make sure that the battery is properly taken care of. Therefore it is strongly recommended that on all batteries in car lighting service one cell be selected and marked "Pilot cell," and the gravity readings of this cell be carefully taken and tabulated as a basis for determining the operation of that battery.

Prob. 72. What precaution must be observed in order to have these readings accurate?

Ans. 72. In order for gravity readings of the pilot cell to be of any use, the level of the electrolyte in this cell must be carefully adjusted to a certain definite point. Gravity readings should not be taken immediately after adding water to the cell. It is necessary to give the battery a gassing overcharge in order to obtain correct readings, for if the gravity reading is taken immediately after adding water to the cell the sample drawn into the hydrometer syringe will be largely water, just added, for, this being lighter than acid, will stay on top.

If the gravity reading is taken with the level of the electrolyte abnormally low, it may show normal gravity of 1.220, indicating full charge, and at the same time the battery may not be up to full state of charge, and had the pilot cell been properly flushed and electrolyte mixed by gassing, a gravity of 1.215 would have been registered.

Allowance must also be made for temperature. The gravity varies one point for every 3 deg. above or below normal temperature of 70 deg. F. A gravity indication of 1.210 at 85 deg. F. (15 deg. above normal) would really be 5 points higher than this if brought to normal temperature and the corrected reading would then be 1.215.

Sulphation.

Q. 73. What happens when the plates of a battery sulphate and what causes this sulphation?

Ans. 73. In speaking of sulphation we refer to the formation of white insoluable lead sulphate formed by the action of the sulphuric acid on the active material in the plates. This should be distinguished from the soluble lead sulphate formed in the plates every time the battery discharges.

This latter is not injurious to the plates, but the former, the white sulphate, is harmful. This is an insulator and as the particles of the active material in the body of the plates are converted into this white sulphate, we not only lose in capacity by the amount of active material actually sulphated, but this sulphated material acts as an insulator to prevent current flowing to or from other particles of active material.

This sulphation may be due to any of the following causes:

(a) Over discharge.
(b) Standing in a discharged condition.
(c) Local short circuit or leakage due to grounds.
(d) Impurities in the cell.
(e) Low charging rate in the Plante type plates, or the omission of the occasional overcharge "F," allowing the level of electrolyte to get far below the tops of the plates.

Sulphated Plates.

Q. 74. How can you tell when the plates have become sulphated?

Ans. 74. Lead sulphate of the insoluble sort is white, so when this is formed in the plates it makes the active material turn slightly grayish or even white in bad cases. The sulphate may also be included by formation of grayish brown patches on the plates.

Treatment of Sulphated Plates.

Q. 75. What should be done when it is found that plates are sulphated?

Ans. 75. If it is found that only one or two of the cells are in a sulphated condition, remove them from the battery and replace with duplicate trays if the car has to go right back into service; then remove the elements from the jars. It will usually be found that there is a short circuit of the plates in that particular cell, due to deep sediment or to tree formation through the separators between plates. Remove sediment or grounds, give the cells one or two overcharges at the normal rate until the plates gas freely. This should be sufficient to break up the sulphate formed in the plates and convert it back again into acid and live active material. Don't under any circumstances add acid to bring the gravity up . . . . it will be found that as the sulphate is decomposed by charging which drives the acid out of the plates, the gravity of the acid will come up to normal of its own accord.

If all of the cells of the battery are in a sulphated condition, it is likely due to having stood in a discharged condition. If the plates are only slightly grayish it may be possible to break up this white sulphate in the plates by two or three overcharges, each carried until the battery gases freely and followed by a successive discharge. If the plates are badly sulphated, as indicated by very light gray or white color, it will probably be necessary to remove the battery from the car and give it several complete charges and discharges in order to bring it back to full capacity.

Some battery operators advocate the use of the alkaline treatment for reducing sulphated plates, but the battery manufacturers state that this does not have any real advantage. For the sake of those who wish to use it, however, we give it as follows:

Remove the plates from the tanks and rinse in water; then place them in clean tanks and pour in a solution of pure caustic soda of a specific gravity of 1.200, formed by adding pure stick caustic soda to water; connect the plates in the usual manner and charge at the normal rate. It is said that one charge in the soda will usually be sufficient to break up even the worst cases of sulphation.

Grounds.

Q. 76. Where are grounds most apt to occur in a battery?

Ans. 76. Grounds may occur either in the car wiring of the battery circuit, on the battery leads, or on the battery itself. They are probably more frequently found to be caused by water slopping over the sides of the tank and bottom of the compartment when filling the tanks. Such a ground may soak through the wooden tank and allow current to flow to or from the lead lining of that tank. If the current flows toward the lining of the tank it will not do any damage, but if it flows away from the tank lining at that point it will cause a pit hole to be formed here, which will eventually cause a leaky tray and a serious ground.

Short Circuits Between Plates.

Q. 77. What causes short circuits between the plates of a cell?

Ans. 77. If the sediment in the bottom of the tank gets too deep so that it touches the bottoms of the plates this is almost sure to cause a partial short circuit. This sediment is composed of active material shed by the plates and, since it is a fairly good electrical conductor, will provide a path for the short circuiting current to flow from plate to plate, as above mentioned.

Certain impurities in the electrolyte cause lead trees to be formed between plates. This tree formation consists of long needle crystals of metallic lead which are formed by the electro chemical action of the current. These trees frequently grow through the holes of separators and make a direct metallic connection between plates; this has just the same effect in short circuiting the battery as if a jumper wire were connected across the cell terminals.

Local Action.

Q. 78. What is meant by local action, and how does it affect the battery operation?

Ans. 78. Local action is caused by impurities getting into the electrolyte. The most common impurities are copper and iron, both of these impurities cause a local discharge in that particular cell in which they exist. This discharge takes place all the time and has very much the same effect as if a jumper wire of more or less resistance short circuited the terminals in that cell. It will cause that cell to slowly discharge, irrespective of the discharge on the other cells of the battery, so that at times that individual cell or cells containing the impurities may show a complete discharge, while the other cells of the battery show nearly full capacity.

Effect of Iron Impurities in Electrolyte.

Q. 79. Explain just how iron impurities in the electrolyte cause a local discharge of that cell.

Ans. 79. When a flake of iron rust falls into the sulphuric acid electrolyte it is immediately dissolved, forming sulphate of iron. This sulphate of iron, however, has the peculiarity of being able to exist in two different states,—ferrous sulphate and ferric sulphate, the latter containing more oxygen than the former. It is very easily changed from one state to the other and in doing so acts as a chemical transfer agent for removing oxygen from the peroxide (PbO_2) of the positive plate, and depositing it on the lead sponge (Pb) of the negative plate, forming (PbO) on both plates. The ferrous sulphate in solution near the positive (PbO_2) plate takes oxygen away from that plate, forming ferric sulphate and (PbO). This ferric sulphate in solution soon diffuses through the electrolyte and arrives at the negative plate which deprives it of the oxygen taken from the positive plate and changes it back into ferrous sulphate. The negative plate, however, in doing so, oxidizes some of its lead sponge active material (Pb), changing it to the oxide of lead (PbO) which represents the discharged condition of that active material. Thus by purely chemical means, the plates of that cell are discharged and the result is practically the same as if a discharge current had flowed through that cell.

Test for Copper in Electrolyte.

Q. 81. How can you tell when a cell has copper in the electrolyte?

Ans. 81. Put the cell on charge for a few minutes and then take a small sample of the electrolyte and put it in a glass test tube or a water glass if this is not available; add pure ammonia slowly, if copper is present in a serious quantity the solution will first turn to a bluish milk color; adding more ammonia will clear up the milk cloudiness of the test sample and turn it to a deep blue clear solution, the intensity of the blue color depending upon how much copper is in the electrolyte.

Test for Iron Impurity in the Electrolyte.

Q. 82. How can you tell when the electrolyte of a cell is contaminated with iron impurity?

Ans. 82. Take a sample of the electrolyte and place it in a glass test tube or a water glass, or even a clean white porcelain cup and add a few drops of a weak solution of potassium per manganate and then add a few drops of a solution of ammonium sulphocyanide. This will cause the solution to turn red if much iron is present and the more iron present the redder will be the solution on test.

Problems for Next Month

Lead Storage Battery Questions Continued.

Q. 83. What should be done with cells containing iron impurity?

Q. 84. What causes one or more cells in a battery to show reversed polarity?

Q. 85. How can you tell when a battery is being seriously overcharged?

Q. 86. What is meant by forming of plates?

Q. 87. What causes the plates "to form and grow?"

Q. 88. What should be done with a battery in which the plates have grown so long that the covers cannot be put in place?

Q. 89. What causes the plates to buckle?

Q. 90. What damage does buckling of plates cause and how should it be remedied?

Q. 91. What are the porcelain blocks on the four sides of the tank for?

Q. 92. Why is it necessary to sweat the lead connector back over the rubber insulation of the connecting leads?

Q. 93. What is meant by hardening of negatives; how can you tell when the negatives of a cell have hardened and what should be done to remedy it?

Q. 94. What is meant by reserve lead in a plate?

Q. 95. Why do the rubber separators have holes?

Q. 96. What is the vent plug in the battery cover for?

Shop Motor Section

Interpole Direct Current Machines

J. H. Wickman

One of the greatest objections to ordinary direct current commutating machinery has always been the sparking at the brushes. Normally the brushes must be placed for sparkless commutation so that they commutate the coils when they are in a position such that the voltage between the coils short circuited by the brushes is zero, this is usually midway between the poles. As the machine is loaded the resultant current flowing through the armature coils forms an electro magnet with its poles at right angles to the primary magnetic axis. This secondary magnetism distorts the magnetic distribution in the pole pieces and causes the magnetism to be concentrated in the lagging pole tip in the direction of rotation. This shifts the commutating axis and unless the brushes are moved sparking will result.

Until a few years ago this sparking could only be counteracted by shifting the brushes ahead, in the direction of rotation of the armature, to the true commutating axis. Theoretically this would require a movement of the brushes for each change of the load on the machine but in practice one position has been made to serve for a variety of load conditions.

Of the many schemes that have been tried in the past to better this condition, the most successful device that has been found is the commutating pole or interpole. These serve to counteract the cross magnetizing effect of the armature as will be explained later and by their use, satisfactory commutation is obtained for all loads with a fixed brush position. From a commercial standpoint this solution is entirely satisfactory. Fig. 1-A shows the poles in position and part (B) of Fig. 1 shows the complete wiring connections used for a large machine of 1,000 to 2,000 k. v. a. capacity.

The number of ampere turns in the interpole is designed for a magneto-motive-force sufficient to provide a field of great enough intensity to neutralize the reactive voltage set up in the armature coils while short-circuited under the brushes. This stops sparking by removing the cause and maintains the proper flux distribution in the pole pieces.

These auxiliary poles are wound to carry a proportional part of the main current, being shunted by the series shunt and the inductive shunt, shown in part (b) Fig. 1. The inductive shunt acts as a reactance in case of a heavy overload and forces more current through the inter-pole windings, thus compensating for all loads automatically. These shunts are not used with some of the smaller capacity machines in which all of the current passes through the windings of the interpoles. Where the inductive shunts are used however, there are several taps brought out so that the machine may be regulated for parallel operation with other machines.

Causes of Sparking of Interpole Machines

Sometimes conditions arise to negative the effect of an interpole, which will usually be revealed by local sparking at one or more of the brush studs, while the commutation at the others will remain good. Sparking could be caused by several things, it could be caused by a short-circuit within an interpole winding which would render that pole inoperative. This could be detected by a resistance test of each of the interpoles to locate the faulty coil and could be located by a resistance test of all the interpoles. Often times with a newly installed machine heavy sparking will be caused by the reversal of an interpole.

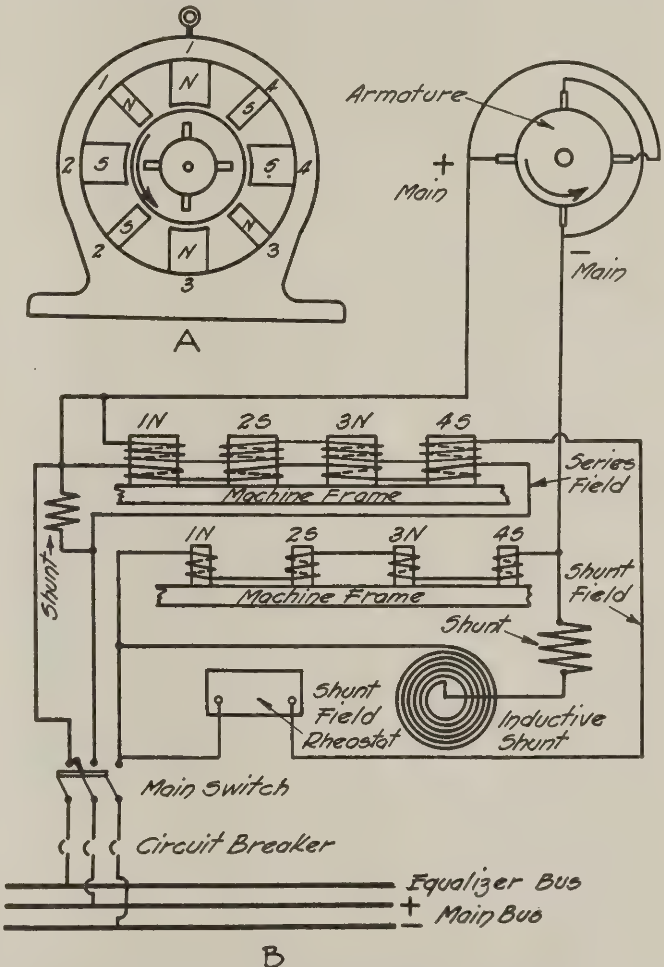


Fig. 1. Wiring Diagram of Interpole Motor Showing Location and Electrical Connections of Interpoles, Series and Inductive Shunts, etc.

In this case the effect on the operation of this one particular brush stud will manifest itself by worse sparking than if the coil were short circuited, because by reversing an interpole it will increase the reactive voltage instead of decreasing it. The reversal of the entire interpole circuit will usually, but not always, be evidenced by heavy sparking at all of the brushes on light loads. A polarity test of the poles will aid in discovering such a reversed condition. This test may be made by bringing a small hand compass near each pole piece while it is strongly magnetized to see that the polarity of each is correct for the given direction of rotation. Any pole with reversed polarity may then be corrected by changing its windings.

The diagram in part A, Fig. 1 shows the correct position of the poles for the direction of rotation shown by the arrow.

When connecting in the interpole circuit, care must be taken to be sure that the polarity of this field is correct with reference to that of the main shunt field, i. e., the connections must be such that a N pole of the commutating field is ahead in the direction of rotation of the N pole of the main field. With reference to the diagram No. 1, N commutating pole lies ahead of No. 1 main pole in the direction the arrow is pointing.

Care and Operation.

The general care, control, operation and maintenance of this type of machine is about the same as any other direct current machine, with the exception that when it is necessary to reverse the direction of rotation by means of the field connections, then the interpoles must also be reversed. These machines will carry a momentary overload of 400 or 500 per cent without undue sparking at the brushes and without flashing over at the brushholders. This is an additional point in their favor, as most modern electrical machinery must have the ability to stand a large temporary overload.

A. B. C. Car Lighting Course

Edited by Edward Wray

Lesson No. 36

Type "F" Safety Equipment

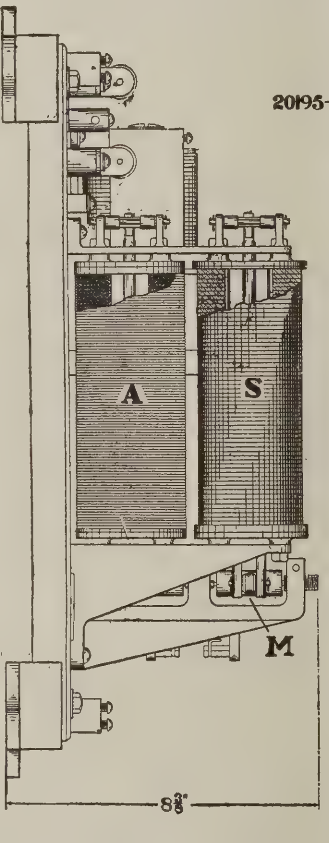
It is without doubt a just criticism of the lessons published so far in this course that they have been rather too general and lacked much of the detailed information necessary for the "man on the job," who has charge of the care and operation of these equipments. Accordingly, we will review a few of the more important axle car lighting equipments and give particular reference to the details of construction, maintenance, operation, replacing parts, etc.

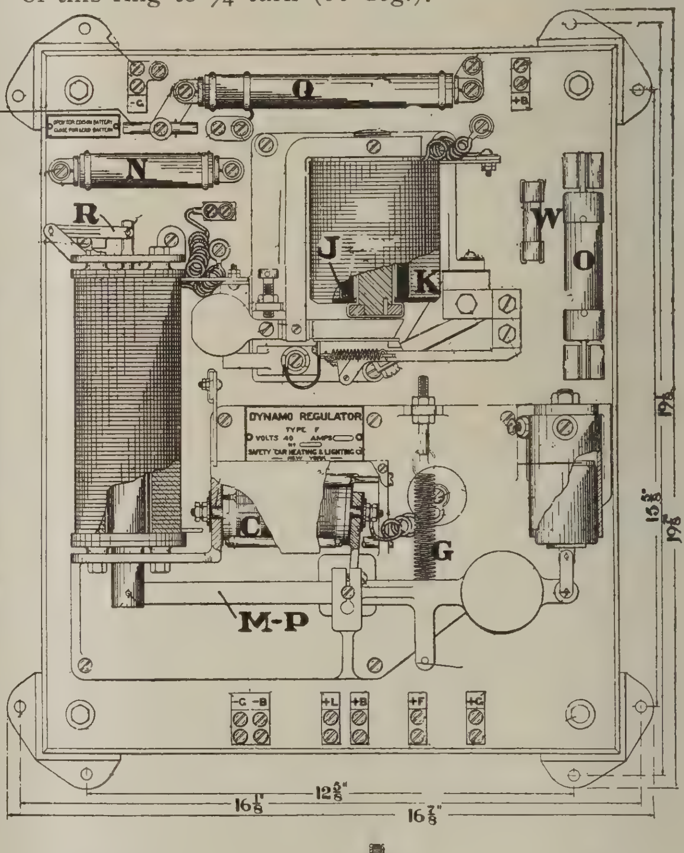
Generator.

The Safety dynamo is a four-pole shunt wound machine rated at 1.0; 2.0; 2.6; 3.0 and 4.0 k.w. at 40 volts and representing generator capacity of 25, 50, 65, 75, and 100 amperes respectively. The 4 k.w. size is also furnished at 80 volts. The four laminated pole shoes with their field coil retainers are fastened to the magnet frame by through bolts with lock washers and nuts. The cast iron heads of the generator, which support the bearings, are bolted to the ends of the magnet frame. Ball bearings, known as No. 412 size, are employed on both the pulley and commutator ends of the shaft. The lubrication of these bearings is effected by grease instead of oil, as used on sleeve bearings and the bearings roll directly in this grease so the lubricant is always at the point needed. How the generator is dismantled, all parts removed and cleaned and ball bearing lubricated, will be treated in our next lesson.

Pole Changer.

The pole changer is of the rotating type, in which the four brush holders are mounted on (but insulated from) a heavy iron ring. This ring in turn is supported by two ball bearings which make the brush holder ring turn very easily. The friction of the brushes is sufficient to cause this ring to revolve through an angle of 90 degrees when the direction of car motion is reversed. Two stops limit the motion of this ring to ¼ turn (90 deg.).





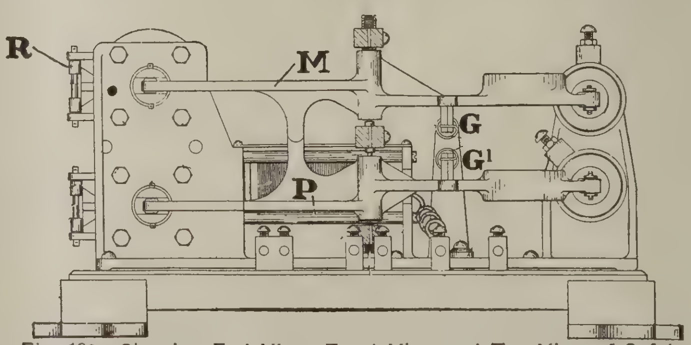


Fig. 186. Showing End View, Front View and Top View of Safety Type "F" Dynamo Regulator Panel.

The principle upon which this pole changer operates is that the polarity of the brushes of a generator alternates between the successive poles of the machine. For instance, if the brush between field pole 1 and pole 2 is positive, that between 2 and 3 will be negative, 3 and 4 positive, and 4 and 1 negative. When the direction of car motion is reversed the polarity of the commutating points of the armature midway between poles will also be reversed and the brush between pole 1 and pole 2 then becomes negative, 2 and 3 positive, etc. But with the reversal of car motion, the brush rig has been revolved 90 deg. so that the positive brush, which formerly made contact between poles 1 and 2, now makes contact between poles 2 and 3 where it receives positive polarity generated by the armature coils at that point. In this way proper polarity of the generator is always maintained regardless of direction of car motion. Three wires, positive generator, negative generator and positive field are brought out through bushed holes in the generator frame and connect to corresponding terminals on the regulator panel. The negative field is connected directly to the negative generator lead inside of the generator frame.

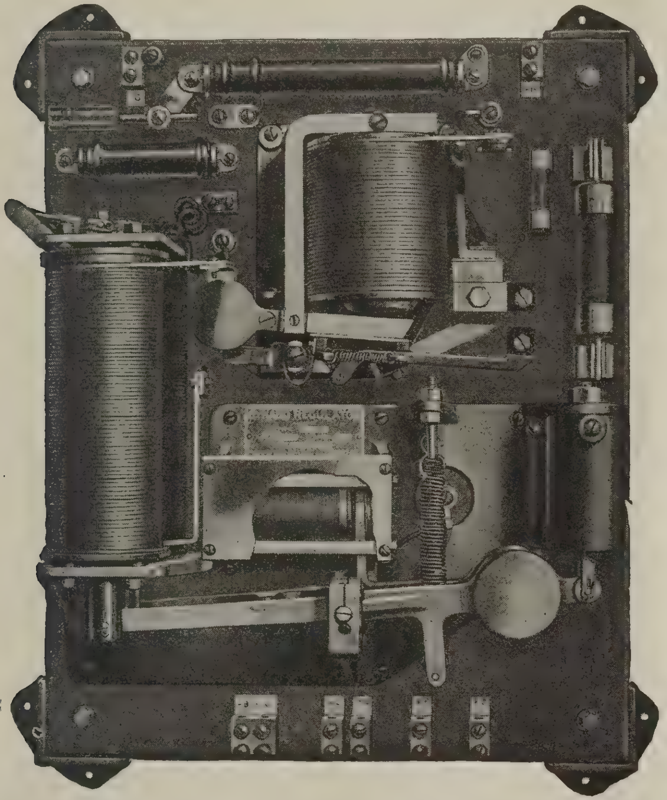


Fig. 187. Safety Type "F" Dynamo Regulator Showing Auto Switch, Current and Voltage Regulating Coils with Air Dashpots at the Right, Both Operating to Control Pressure on the Carbon Pile in the Center of the Board.

Automatic Switch.

The automatic switch consists of a fine wire lifting coil (J, Figs. 186 and 188), connected directly across the generator terminals; another coil (K), of heavy ribbon copper is wound outside of this shunt coil and this is connected directly into the generator circuit and carries full generator current. This is known as the "kick-off Coil" for when the generator voltage falls below that of the battery a reverse current will flow back through this coil from battery to generator and this current will generate magnetism in the kick-off coil which will neutralize the shunt coil magnetism and cause the switch to drop open.

At the bottom of the magnet frame or yoke is pivoted a movable iron armature to which is attached the laminated conductor of the switch. The core, yoke and armature compose the magnetic circuit of the switch.

Flow of current through the lifting coil induces in the iron core, a magnetic force, the value of which varies with the amount of current flowing through the lifting coil. At a generator voltage of 34 volts the current through the lifting coil will have produced a magnetic flux of sufficient strength to lift upward the movable iron armature and bring its laminated conductor into contact with a stationary brass contact block on the switch frame. These two contact surfaces are protected by renewable secondary carbon contacts and all arcing in opening or closing the switch occurs between the carbons instead of on the copper brush. When the switch closes, current flowing through the series coil from generator to battery and lamps will increase the magnetic pull of the lifting coil and pull the switch closed solid, giving the laminated copper brush a wiping contact.

The lifting coil is connected in series with resistance unit "N" Fig. 188, and the circuit is then connected across the generator leads. The switch is set by the manufacturer to close at proper voltage, and no adjustment should be necessary.

Dynamo Regulator.

The generator regulator is what is known as the combination current voltage type which produces a taper charge in which the charging current to the battery with no lights on starts at about 60 amperes at the beginning of charge and as the voltage rises on charge after about 5 hours, the charging current begins to taper off to a low value of approximately 10 amperes, depending upon the setting of the voltage coil.

The carbon pile "C" Fig. 188, is connected in series with the generator field circuit and the resistance of this carbon pile is automatically increased or decreased by releasing or increasing the pressure on the carbon pile. The pressure on this carbon pile is produced by the magnetic pull of the coils "S" or "A" on their plungers. It should be noted that balancing weights are mounted on the right hand end of each of these lever arms. These, together with the weight of the dashpot plungers, exactly balance the weight of the solenoid cores, so that in passing over rough track there is no vibration of the regulating parts due to an unbalanced condition.

On the front (or current-regulating) lever arm (M, Fig. 186), is a finger projecting inwardly toward the panel and so placed as to be directly under a similar outwardly projecting finger on the rear or voltage-regulating arm (P). These two fingers are separated by about 1/32 of an inch when the machine is inoperative, the position of the front arm then being determined by a stop on the guide lever (R) at the top of the solenoid frame. This "stop" should rest on the solenoid frame at this time, and the position of the rear arm will then be determined by the length of (number of discs in), the field carbon pile.

Movement of the rear lever arm (P), is transmitted directly to the carbon pile, pressure on which is then increased or decreased depending upon the direction of plunger movement. The front lever (M) however, is not connected directly to the carbon pile, but its movement is transmitted through the two projecting fingers to the rear lever arm, and thence to the carbon pile.

Movement of the plungers and lever arms is dampened by two dash-pots (one connected to each arm) of the "air-dash" type. In the side of each dash-pot shell is drilled a small hole to permit escape of air, this feature being made of graphite and must be handled carefully to avoid injury to their surfaces. The dash-pot shell should always be so applied that the vent holes point to the front, or nearly so, to facilitate inspection. Each plunger is accurately fitted to its own shell and these parts are not interchangeable, consequently, repairs to the same should always be made by the manufacturer.

Lamp Regulator.

It requires practically 39 volts to fully charge a lead battery with this equipment, so at the end of charge the generator will deliver this voltage. The lamp voltage, however, must be maintained constant at 32 volts whether the battery is in a low or full state of charge, so a lamp regulator is employed to automatically absorb the over-voltage of the generator, which varies from 35 to 39 volts, and provide a constant voltage of 32 volts at the lamps. This is accomplished by connecting a double carbon pile in series with the lamp circuit, as shown in Fig. 189 and EE as in Fig. 190. These two carbon stacks are connected in parallel so as to divide the lamp current between them and to give heavy capacity to the lamp regulator. The resistance of these stacks decreases as the pressure is increased and this pressure is adjusted to proper value by means of an electro magnet consisting of a voltage coil across the lamp circuit terminals. When the generator voltage is highest (39 volts), the pressure on the carbons is a minimum and their resistance is accordingly greatest in order to absorb the 7 volts difference between normal lamp voltage of 32 and generator voltage of 39. This electro magnet, Fig. 190, involves a lamp voltage coil (T), partially encased in a stationary iron frame, and a movable armature (U), mounted on a pivoted crank block. The crank block is mounted on enclosed ball bearings and is connected through a link (20148), to a pressure plate (7074), at the left end of the carbon piles, the right hand ends of the carbon piles being stationary against a contact plate. On the left end of the link (20148), is a corrugated nut (7091), by means of which the initial setting of the carbon resistance is made.

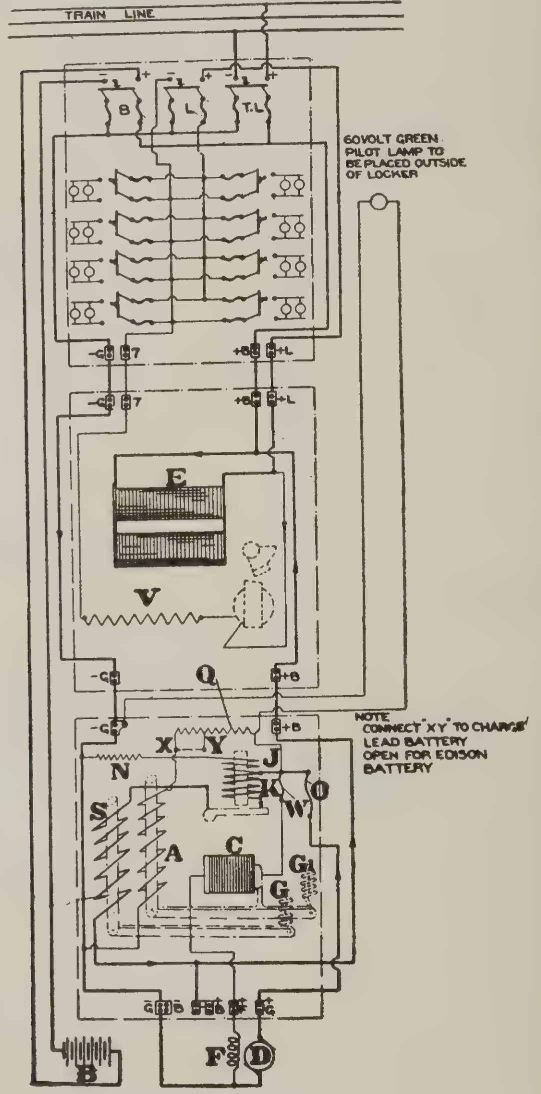

TRAIN LINE
B
L
T.L
60 VOLT GREEN PILOT LAMP TO BE PLACED OUTSIDE OF LOCKER
-G
7
+B
+L
E
V
Q
NOTE CONNECT "XY" TO CHARGE LEAD BATTERY OPEN FOR EDISON BATTERY
X
Y
J
N
K
O
W
S
A
C
G1
G
F
D
B

Fig. 16 Wiring Diagram of 40-volt Type "F" Regulators

Fig. 188. Wiring Diagram of Safety Type "F" Equipment Showing Dynamo, Battery, Dynamo Regulator, Lamp Regulator and Lamp Circuit Switches.

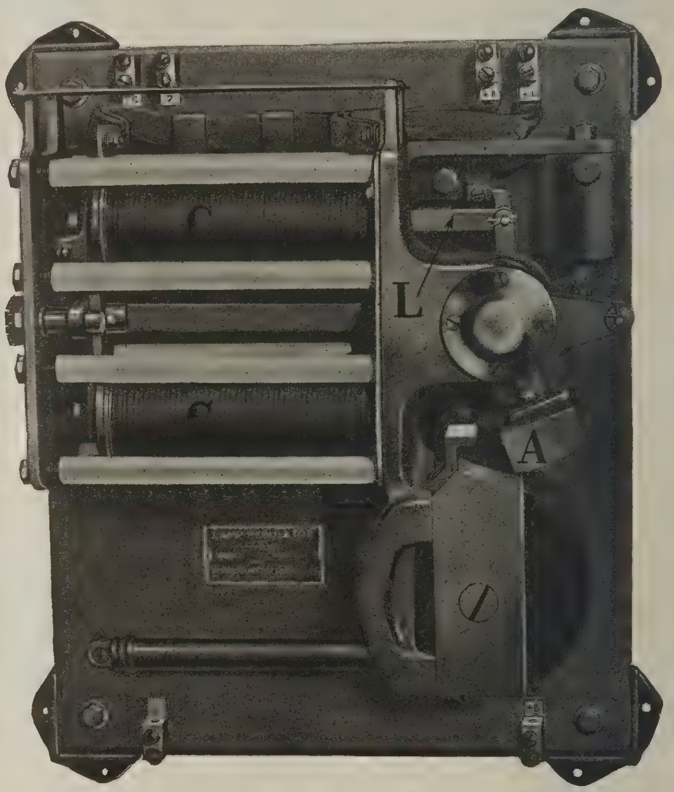


Fig. 189. Lamp Regulator Showing Main Solenoid, Pivoted Armature "A," Spring Tension Rod "L" and Carbon Pile Resistance "C."

Movement of the armature is opposed by a spring not shown, but located directly back of the top carbon pile, and is limited for minimum pressure (low voltage) on the carbon pile by the stop (H) and for these two extreme positions of the armature correspond respectively to maximum and minimum generator voltage. This spring connects with the link (L) Fig. 189.

All lamp current flows through the two parallel connected carbon piles, whose resistance (pressure) is so varied by the electro-magnet that any excess voltage impressed upon the lamp mains by the generator or a charging line is dissipated in the carbons, so as to operate the lamps at the desired voltage. The spring tends to maintain maximum carbon pressure (minimum resistance), while the magnet tends to produce minimum carbon pressure (maximum resistance); thus, the two forces are opposed, and the spring tension is to be so adjusted that they will be equal when the lamp voltage is 30. The magnet coil (T) is connected in series with a resistance unit (V) and the circuit is then connected directly across the lamp mains.

Adjustments

Automatic Switch.

The automatic switch is set by the manufacturer to close at 34 volts on 30 volt equipments and 68 volts on 60 volt equipments. No adjustment in service should be necessary, but if it is found necessary to make an adjustment, this should be made at the stop at the left of the hinge pin; raising the stop makes the generator cut in at a higher voltage, and lowering it makes it cut in at a lower voltage. The position of the iron core should not be changed to make any adjustment since when properly set the bottom of the core, contact block and top carbon block are all on the same horizontal line. This is necessary in order to insure that the copper brush will be drawn up solid so as to make a good wiping contact.

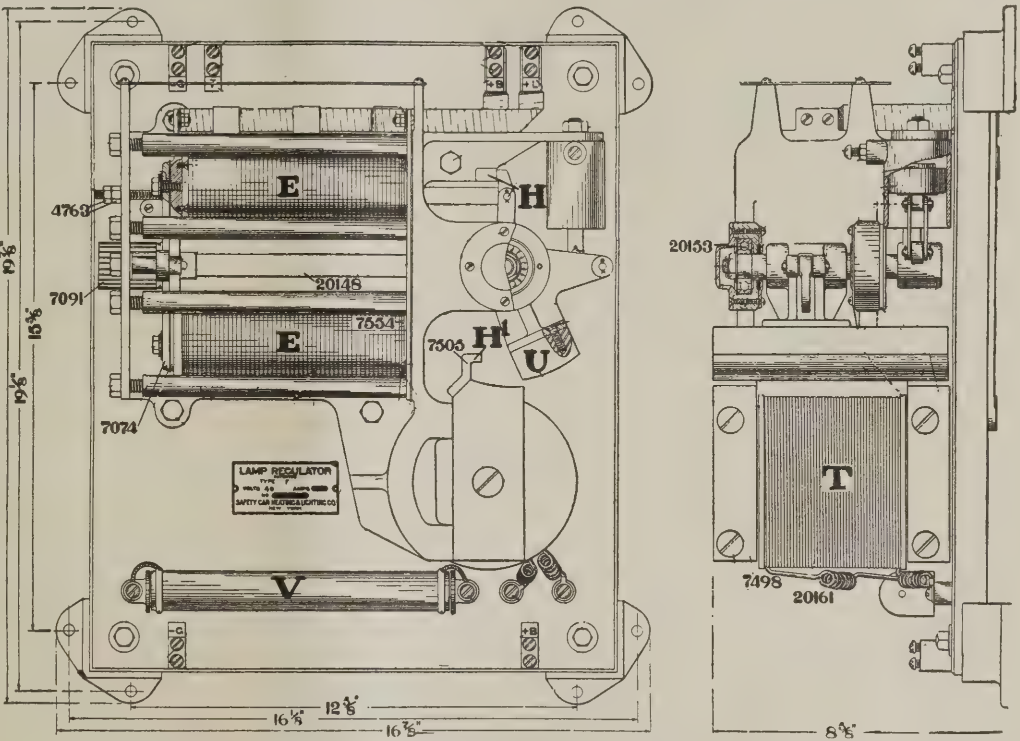


Fig. 190. Showing Front View and Side View of the Lamp Regulator Shown in Fig. 189.

Generator Voltage Regulating Coil.

The adjustment of this coil is set at the factory so that it regulates at 39 volts on 30 volt equipments with lead batteries, and at 78 volts on 60 volt equipments with lead batteries. When Edison batteries are used, this voltage is raised to 43 volts and 86 volts, respectively. By opening the short circuiting device (2015, Fig. 186). This cuts in the additional resistance at the left hand end of resistance element "Q" and so requires a slightly higher voltage on the generator to force normal current through the voltage regulating solenoid. This device is on the upper left-hand corner of the regulator and is marked "Open" for Edison battery; "Closed" for lead battery.

In order to check the setting of this voltage coil "A," Fig. 188 first; be sure that no current is passing through the current coil "S." This can be done by placing a sheet of insulating material between the contacts of the main switch; then no current is passing through the current coil, and the stop on its plunger rests against the top of the coil head. With the above conditions—the car running at a speed of 30 miles an hour or more—the voltage across the GG terminals on the regulator should be as given in the preceding paragraph. If the voltage is not correct it should be adjusted by the spring "G^1," Fig. 188 .

To check the setting of the current coil "S," connect an ammeter at the "-G" terminal of the regulator. If the stop on the plunger guide of this current coil "S" is raised from the coil head, the coil is regulating and the ammeter will show at what current the coil is regulating. If the stop is against the coil head, compress the field carbons by hand through the voltage coil lever, and note the current at which the series coil plunger begins to rise. This is the current at which it will regulate, and should be within the rating of the dynamo.

The number of field carbons should be such that, when the car is standing, and the carbons are tightly compressed by the spring of the voltage solenoid, it is possible to slip a field carbon $\frac{1}{64}$ in. thick—between the projections on the levers of the voltage coil and series coil.

Lamp Regulator.

To adjust the lamp regulator it is first necessary to get rid of all magnetism in the operating magnet, which can be accomplished by disconnecting the battery wires from the regulator panel, or by disconnecting one of the leads of the coil (T, Fig. 190). Hold a small wrench or other piece of iron up to the front magnet coil head, and if it shows no tendency to adhere to the head, current is off the board, which is the condition aimed at. Next remove the air dashpot, using special care to not injure the graphite plunger, leave the plunger hang loose on the arm and short circuit the two terminals marked "+ B" and "+ L" at the upper right hand corner of the board. An ordinary link fuse of 65 or 75 amperes capacity, or a piece of No. 12 copper wire, makes a convenient jumper for short-circuiting the two terminals, but it is necessary in any case that the jumper be clamped solidly under the terminal screws. Next unscrew the corrugated adjustment nut (7091), until the armature (U), can be moved smoothly throughout its full arc of travel, then screw up very slowly (one notch at a time) on the adjusting nut (7091), until the armature will not quite go back against the top stop H_1, Fig. 190, after which the adjusting nut should again be unscrewed one-half turn and locked in this position by means of the clamping screw 4989; don't screw this so tight as to bind on the corrugated nut. The armature can now be moved through its complete arc of travel. To adjust the spring tension it is first necessary to get current on the panel and through the lamps, but without removing the short circuiting jumper from the two terminals at the top of the board. Then, with a voltmeter connected to the two mains of the lamp switchboard, turn on or off lamps until the instrument indicates 30 volts, at which time the tension of the spring should be so adjusted (by manipulating nut 4763), that the armature will remain in any position throughout its stroke. The operator must maintain 30 volts at the lamps while adjusting the spring, by varying the current as may be necessary.

Next remove the short-circuiting jumper, replace the dash-pot (taking care to place it with the vent-hole at the front), and note the lamp voltage as indicated on the voltmeter. If the drop across the carbon pile exceeds 2 volts the carbons should be removed and the dust blown off the discs, *but do not sandpaper the discs.* If this does not reduce the drop, tighten up one or two notches on the adjusting nut (7091). Next turn on all lamps and put the car on charge at a high rate (60 to 70 amperes on a 30-volt coach or postal car, 80 to 90 amperes on a dining car), to obtain a charging pressure of 37 to 40 volts, and note the lamp voltage as indicated by the voltmeter. If it exceeds 32 volts the setting is incorrect and must be done over, or there is some defect in the regulator which should be remedied.

We are indebted to Mr. J. R. Sloan, engr. elec. car lighting of the Penn. R. R., E. E. Goddard, ass't. engr. elec. car ltg. P. R. R., and the engineering department of the Safety Car Heating and Lighting Co. for their co-operation in preparing this article.

(The subjects of operation, dismantling, cleaning, etc., will be taken up in our next lesson.)

Prize Question Box

This "Question Box" is open to every electrical man in the Mechanical, Signal and Telegraph, as well as Car Lighting Departments. We feel that this can be made a mighty valuable thing, so as a special inducement to the boys to boom it, we offer prizes for the best questions asked, as follows:

First prize ....$1.00 *in cash*
Second prize ....9 *months' subscription*
Third prize ....6 *months' subscription*

There are some questions that are of a general nature, which should have comments of prominent men of experience. These will be published under "Questions Before the House," and we hope that prominent railroad men and manufacturers will discuss these questions. All answers published will be paid for at $1.00 *each.*

Questions Before the House

Grounded Field Coil in Moskowitz Generator.

No. 10—While motoring a Moskowitz generator, the automatic switch, after being closed, had a tendency to stick quite tightly in position and immediately release, in the same revolution of the armature. This effect was maintained as long as the switch was held in the operating position. In motoring this machine in the opposite direction, it was found to work perfectly. After carefully looking over the generator, it was observed that one field-coil was grounded. After removing the ground, the auto switch worked perfectly in either direction.

What caused the automatic switch to act in this manner? Why did the grounded field coil effect its operation only in one direction?—H. W. Millard, Santa Fe.

Ground on Type "K" Relay.

What effect will a ground on a type K relay have on the operation of the U. S. L. equipment?—Frank M. Burke, Pullman Co., Jersey City.

What Is the Life of a Storage Battery?

In traveling about the country I hear a good many arguments, and, while most of them are usually settled in some manner, there is one question which no one has ever offered an answer to that seemed to cover it definitely.

It is impossible to mention batteries without referring to their life and up to the present I have never met anyone who can bring forward any method of computing it that would be considered practical.

Like everything else, I believe some standard should be agreed upon in connection with the life of a battery whereby anyone should be able to determine when a battery is fit to continue in service.

By the above statement I do not mean that a person should be called upon to guarantee the life of any battery, but I do claim that when the efficiency or capacity has dropped to a certain point, it would then be considered fit for scrapping.

A good many men consider a battery useless only when the parts have refused to hold together any longer. This is unfair, as I have already seen elements which appeared as good as new, but which were unable to deliver over 1-5 of their rated capacity.

We consider an incandescent lamp worn out when it has dropped to 80% of its initial candlepower. How about 60% A. H. efficiency at the 8-hour rate?

A Car Lighting Batteryman.

Ampere Hour Meters in Car Lighting Service.

What attention has it been found necessary to give ampere hour meters in car lighting service to maintain them properly? How frequently should they be removed from cars and taken into shop for thorough overhauling?—L. S. Billau, B. & O. Ry.

Practical experience with the ampere hour meter in vehicle service has shown that except in special cases they will run 3 or 4 years, or possibly longer, without any attention. It is a simple matter to check the operation of the meter, for with an ammeter in circuit and counting the number of revolutions per minute of the meter disc and knowing the meter constant, the accuracy of the meter can quickly be determined. In case this is found to be more than 5 per cent in error, it should be either sent back to the manufacturer or given an overhauling by a competent man.

If the mercury becomes dirty, due to oxidization or other causes, it will cause the meter to run slow. This is a rather unusual occurrence, but if it is found to cause trouble, the mercury can easily be changed by a person understanding the construction of the meter, in about 10 or 15 minutes. Only the purest mercury should be used for replacement. Commercial mercury bought on the market will usually contain lead and other impurities.

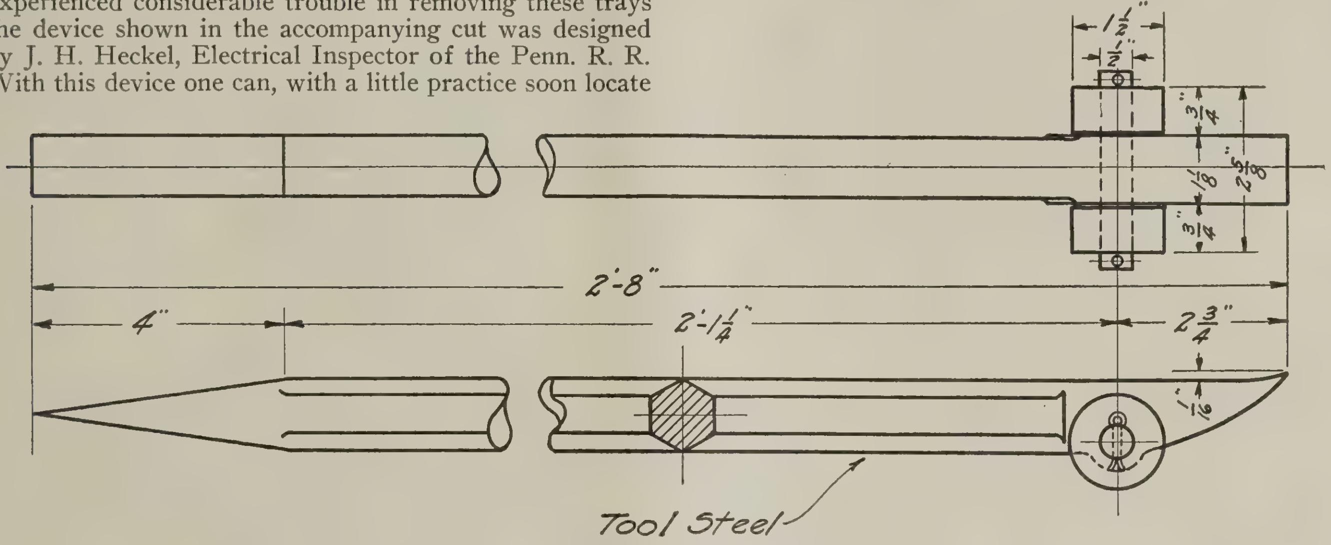
In the earlier meters installed in car lighting service some trouble has been experienced, due to the high temperature in regulator lockers caused by lamp and field carbon piles. With the earlier meters employed the mercury chamber was made up of a shellac-mica composition. Temperatures such as found in many car lighting lockers have been sufficient to soften this compound and the chamber and meter shaft bearings have become distorted, causing the meter disc and shaft to bind and stop the meter or cause it to run abnormally slow. In the meters now placed on the market, however, the mercury chamber is constructed of condensite, which will stand a temperature of 360 deg. F. without softening, so further troubles of this nature should not be experienced in the future.

Practical Stunts

We Pay a Dollar Apiece for Practical Stunts—Send in Your Ideas

Easy Method of Removing Battery Trays.

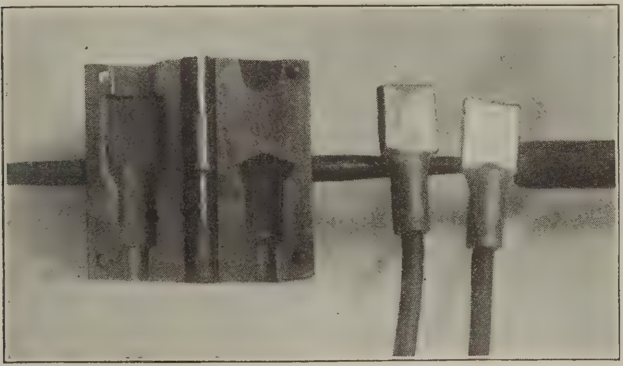
Battery trays equipped with skids, as is the present practice, are often very hard to pull out. After having experienced considerable trouble in removing these trays the device shown in the accompanying cut was designed by J. H. Heckel, Electrical Inspector of the Penn. R. R. With this device one can, with a little practice soon locate the pry under the center of gravity of the tray and remove it with very little difficulty.—H. C. Mawheiney, Buffalo, N. Y.



Crowbar with Roller Pivot for Handling Battery Trays.

Lead Terminals Cast Directly on Cable Connectors.

In the November number of the RAILWAY ELECTRICAL ENGINEER there was a stunt published by H. G. Meyers relative to the burning of battery connectors. It may be interesting to other battery men to know how these connectors are prepared.



Mold for Casting Lead Terminals on Cable Connectors and Two Connectors with Cast Terminals in Place.

Five years ago we decided to find some better connector than the old style ones having copper terminals bolted together with brass bolts. Mr. Everett finally hit upon the plan which we have used ever since,—that of casting lead terminals directly on the cable connectors and then burning these to the terminal posts.

The mould to cast these terminals is made as follows:—Take two pieces of brass ¾x1¾x4 in., cut out the two faces as shown in the illustration and hinge the two halves together. Into the center of each of the edges opposite the hinge screw a piece of ½ in. cold rolled steel rod 12 in. long. On the ends of these rods fit wooden handles.

With the mould ready for use cut the wires to the proper length and skin the ends back ½ in. The ends can be easily and quickly tinned by dipping them in the flux and then into melted solder. Leave the ends in the solder until they become hot enough to tin properly but be careful not to overheat the rubber as it will then swell and be ruined.

In placing the connector in the mould see that the end of the wire extends far enough into it to allow the lead to run down and form a ½ in. skirt about the rubber, which will prevent acid entering at this point.

After making the casting inspect it; first, to see that there are no blow holes into which the acid might enter; second, to see that no stray ends of wire extend through to the surface; and third, catch the flat end in a vise and pull on the wire to make sure that the lead has made a strong bond with the wire.

It is best to use a hard lead containing antimony as this is more easily burned to the posts and also makes a better union with the wire. We obtain our lead by melting up old battery plates, Manchester positives being especially good for this purpose.—C. B. Jennings, Topeka, Kans.

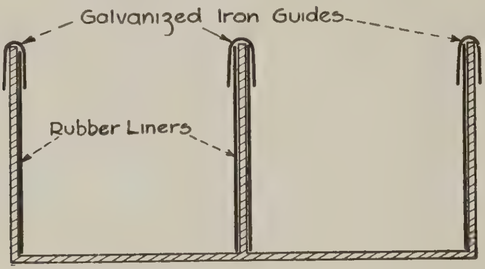
Easy Way of Removing Lock Nut From an Armature.

Generally when the lock-nut is removed from an an armature it requires the aid of a helper and the windings are in danger of being damaged by its being rubbed and twisted about upon the floor.

Here is an easy method of avoiding this trouble: Take a scrap pulley and bore several holes in the flange, then place the pulley on one end, and by means of these holes bolt it or screw it to the floor. Take the armature and place a key in the keyway on the shaft and fit it into the pulley. This holds the armature in an upright position and the lock-nut can be removed without the aid of a helper.—H. B. Reed, Pullman Company, St. Louis, Mo.

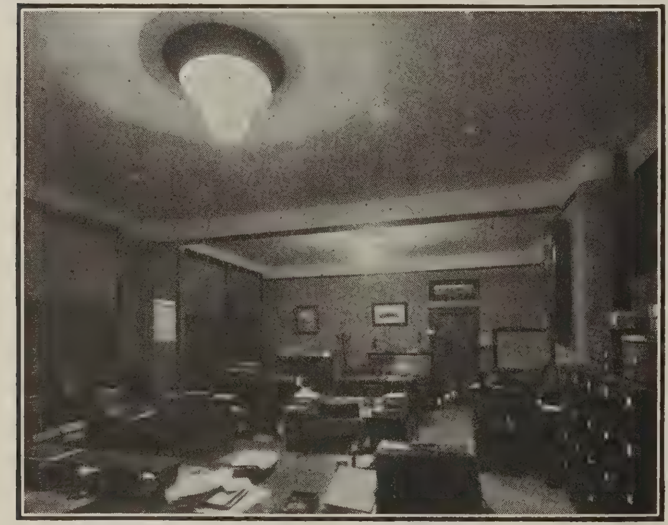
Quick Method of Placing Liners in Battery.

Battery men often have difficulty in placing the rubber side and end liners in the tanks because the bottom plate supports may be so near the sides that the liners will wedge in being inserted. I have found that it saves considerable time to use the galvanized iron V-shaped guides, shown in the diagram. The liners are first inserted, the guides are then put in place, when the plates can be put in place without difficulty.—E. W. Breese, Penn. Ry.



Gas Filled Mazdas for Lighting Railroad Offices

The accompanying illustration shows fairly well what can be accomplished in the use of large units for office lighting. This office is 22x34 ft. and the units are placed approximately 9 ft. from each end. The units consist of a 350-watt nitrogen filled mazda, mounted in "Brascolite" fixtures. This consists of a medium density opal diffusing bowl suspended below a white porcelain enameled reflecting surface. The unit is a semi-indirect one, the bowl hanging about 6 in. from the enameled reflecting surface. This fixture is manufactured by the Luminous Unit Co., of St. Louis.


Office Telegraph Dept., C., R. I. & P. Ry. at Chicago.

These two 350-watt units represent a little less than one watt per sq. ft. of area illuminated, and they furnish an illumination which is very brilliant and in which the shadow effects are minimized. Where formerly there were approximately 20 drop lights and 2 center clusters, all drop lights and clusters have now been eliminated. The great abundance of illumination is roughly indicated by the fact that it took an exposure of but 5 minutes with the F-16 stop to expose the plate, from which this picture was made. Ordinarily it takes from 15 minutes to half an hour to make such a photograph. Note the clearness with which the details in all parts of the room can be discerned.

E. A. Humphrey

The many friends of Mr. E. A. Humphrey will be pleased to learn of his appointment as electrical engineer of the Great Northern Railroad. Mr. Humphrey has been in railroad service for over 15 years. He began his railroad career as a "head-end" electrician on the Lake Shore Limited between Chicago and New York, and held this position from 1889 to 1904, at which time he was appointed electrical foreman in charge of car lighting at the Root Street yards of the Lake Shore & Michigan Southern R. R.

E. A. Humphrey.

In 1909 he was appointed chief train electrician of the Great Northern R. R., and had charge of all car lighting equipment on that road until 1911, when he was appointed chief electrician of the Cascade Tunnel Electrification of the Great Northern. In this capacity he had charge of the installation and operation of the electrical equipment at the tunnel until November, 1914, when he was appointed electrical engineer of the Great Northern.

Mr. Humphrey's advancement in railroad circles is particularly interesting in view of the fact that he has developed from the car lighting department to having charge of the operation of all electrical equipment on the road, including an important electrified section.

William F. Bauer Appointed Manager Chicago Office Edison Storage Battery Co.

Mr. William F. Bauer, who has been with the Edison Storage Battery Co. for about a year as assistant manager of the railway department, has now been appointed manager of the Chicago office, the territory of which includes the entire central district of the United States.

Mr. Bauer is president of the Railway Electric Supply Manufacturers Association and his many friends will be pleased to learn of his present appointment.

With the Manufacturers

New Pendant Fixture for Station Lighting

With the recent introduction of the new gas filled mazdas, which have an intensely brilliant filament and which also require special ventilation, it has been found necessary to design a complete new line of lighting fixtures to accommodate these lamps.

A new fixture recently placed on the market by the Benjamin Electric Mfg. Co., of Chicago, as shown in the accompanying illustration has been designed for special use in lighting large areas indoors, such as in railway stations, offices, etc.

The fixture is built along plain but ornamental lines and consists of a 6 in. x 8 in. stalactite globe which, with the ventilating hood, is supported by a link chain with swivel at the top. A hole in the bottom of the globe provides both an entrance for the flow of ventilating air currents and also an exit for dirt, dead bugs, etc., which usually collect in lamp globes. It should be noted that the taper of the globe is steep enough so that the dirt will slide out of its own accord.

The fixture is designed for type "C" mazdas ranging from 200 to 300 watts and has provision in the hood for ample ventilation. This unit measures 27 in. overall and is an addition to the line of ornamental fixtures which has recently been designed for this new high candle power lamp.

New Benjamin Station Lighting Unit.

Edison Storage Battery Buildings Uninjured by the Fire in Edison Works.

The fire that destroyed part of the Edison Phonograph Works at Orange, N. J., on Dec. 9th, did not in any way affect the buildings of the Edison Storage Battery Company. One end of the large concrete buildings of the battery works is across the street from Mr. Edison's private laboratory which was saved, and this as well as the rest of the plant escaped unscorched. The fire started about 5:20 in the afternoon, and was well under control by 10 o'clock. The telephone exchange was in one of the burned buildings, but through the prompt action of the New York Telephone Co. a temporary switchboard was working in the battery office before business hours the next morning, and the Public Service Electric Co. had emergency lines furnishing power about as quickly. The business of the Edison Storage Battery Company, therefore, suffered no interruption whatever.

D. & W. Magnetic Chucks

As a labor saver, there is probably no form of electrical device that has proved of greater benefit in the machine shop than the magnetic chuck. It possesses a very wide range of usefulness in holding steel and iron pieces for grinding, planing, shaping and milling. When a large number of pieces are to be machined, it will frequently be found that the time and labor saved by the use of this device as compared with the old time methods of clamping, bolting or holding one piece at a time in a vise, will pay the entire first cost of a chuck within a short period of service.

D & W Magnetic Chuck for Holding Material While Being Worked.

The D & W Fuse Co. manufacture an extended line of flat, vertical and rotary chucks. The flat chucks have a horizontal face and are equipped with adjustable end and side stops, providing convenient means for locating and steadying the work on the surface of the chucks. They are particularly useful in holding work for grinding, such as file blanks, scale blanks, thickness gauges, punches, dies, knives for wood working machinery, accurate shims, gibs, or practically any work on which it is necessary to grind flat surfaces. Thin stock can be held for grinding on one face without the distortion due to clamping the edges.

Milling operations can be performed with great facility where the shape of the work is such that the end stop of the chuck can be raised to take part of the thrust. When used in this way a small flat chuck will hold a 1 in. x 2 in. x 6 in. bar of tool steel strongly enough to mill .050 in. off the surface 2 ins. wide, with a feed of 1 in. per minute.

The rotary chucks are also especially adapted for grinding pistons, and piston rings to fit the ring grooves, with the utmost accuracy.

With some earlier products of magnetic chucks much trouble was experienced by the burning out of the magnet coils when subjected to variations of voltage, moisture or prolonged service.

"The House

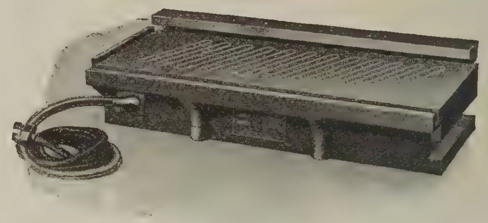
Your entire requisition for electrical supplies with one order and you receive the goods in

"Alexalites"

Alexalites are ideal units for office and station lighting. With them you can enjoy all the benefits of the Gas Filled Mazda lamps without the glare and eye strain.

Alexalites are easy to clean, strongly built (no glass), highly efficient, therefore, most economical.

D. & W. Magnetic Chucks



Heat, Oil and Waterproof Chucks for Every Purpose

There's a D. & W. Magnetic Chuck to meet your requirements—flat, vertical and rotary styles, proof against moisture, oil and heat. Holding power greater than ever before secured in magnetic chucks of equal size. Wide capacity, true and accurate in operation, holding heavy work rigidly and light pieces without distortion. Provided also with auxiliary plates to be used as fixtures in holding odd shapes, etc.

Send for complete information.

"D. & W." Chuck Coils are wound with "Deltabeston" (asbestos covered) magnet wire, and coil units are interchangeable.

Central Electric Company

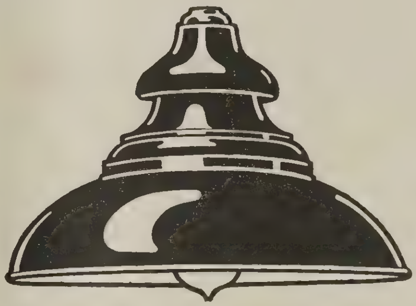
320-326 So. Fifth Avenue Chicago

# of Service"

on any job, no matter how large, can be covered one shipment. Think of the convenience!

OKONITE

TRADE MARK.



The "Maxolite"

Insulated wire for railway signals, car lighting, shop and terminal light and power service must be absolutely dependable and have the highest insulating qualities — this is just another way of specifying Okonite. It has for years been the standard in railway service.

Okonite Insulation contains never less than 30% of the best quality dry, fine, up-river Para rubber and is made in but one grade, only—**The Best.**

Designed for that railroad electrical engineer who demands greatest efficiency, ease of installation and a gas and waterproof fixture built in

One Piece

It is well ventilated for use with Type "C" Mazdas. With the Type "R" Fitting, makes it possible for a one-armed man to install it. Specially adapted for,

Shops	**Trainsheds**
Yards	**Roundhouses**
Platforms	**Warehouses**

Ask for Bulletin No. 43

Central Electric Company

320-326 So. Fifth Avenue Chicago

FARADAY
BELLS AND BUZZERS

ELECTRIC HEATING DEVICES

RALCO
PLUGS
AND
RECEPTACLES

To eliminate this annoyance the magnet coils in "D & W" chucks are wound with Deltabeston Wire, having a special heatproof insulation of pure asbestos, which they manufacture. This insulation can safely withstand temperatures as high as 400° Fahr. In addition, the coils are wound by a special process which still further protects them from heat and moisture.

With the exception of the smaller sizes, the chucks are designed for use directly on 105-125 volt direct current circuits. Where it is desirable or necessary to energize them on circuits of higher voltages, such as 210-250 volts, there is supplied a convenient form of auxiliary resistance which may be inserted at any suitable point in the circuit. The small chucks are equipped with standard external resistance units for use on 105-125 volt direct current circuits.

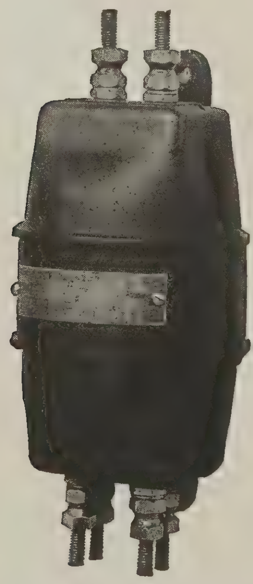
"D & W" chucks are both oil proof and water proof, and are equipped with demagnetizing switches for readily releasing the work. These demagnetizing switches are independent units and may be mounted at any point convenient for the operator. By a simple movement of the lever positive demagnetization is effected.

Magnetic chucks can only be operated on direct current circuits, and under no conditions can alternating current be used. Where direct current is not available, a direct current generator can be belted to the line shafting of the shop in which the chuck is to be used. These small generators run without any more attention than a fan motor requires, and occupy but little more space. From one to twelve chucks can be operated from one generator, depending on the style of chucks and the size of the generator.

The Central Electric Company of Chicago, Ill., general western distributors for the D & W Fuse Company, will take pleasure in mailing Circular 203 to any one interested, on request.

Signal Lighting Transformers.

A new line of miniature air cooled transformers, known as type M, has been developed by the General Electric Company for railway signal lighting.


Indoor Lighting Transformer.

Lighting Transformer for Outdoor Service.

These transformers are distinctive in application and design. They are enclosed in a neat and compact case, either for indoor use or in a weatherproof form for outdoor use.

The transformers are fitted with standard R. S. A. terminals, as shown by the accompanying illustrations, and are furnished in sizes for 25 to 125 watts, 25 and 60 cycles.

A lamp of from 2½ to 5 watts is generally considered sufficient for signal illumination; consequently, a transformer of this kind with 6 to 12 volt, 2½ to 5 watt, high efficiency Mazda lamps makes a very satisfactory, as well as economical, system of lighting.

New Western Electric Catalogue.

The Western Electric Company starts the new year by distributing the first edition of its 1915 electrical supply year book. In the past it has generally been the practice for jobbers to issue a catalogue not more frequently than once in every three years, but the Western Electric Company has adopted the policy of an annual catalogue, which it believes will serve to give the industry the greatest amount of information obtainable on the materials which it uses.

This book makes another departure from the usual practice—it replaces the manufacturers' list prices which have usually accompanied catalogues of this sort. The wide variety of differing discounts has always been an objectional feature of catalogues and in this book complete series of list prices are announced, upon which, a uniform basic discount applies.

To those in the electrical field this means a reduction in operating cost in that the method of estimating on material and purchasing and sale of supplies is simplified. This book is easy of reference as well as complete in its listing and contains more than 1,200 pages besides an alphabetical index.

One of the features of the book is an advertising bulletin embracing examples of advertising and selling helps which the company furnishes to its agents in connection with the sale of goods carrying its firm trade name. This includes the listing of electros for newspaper advertising, street car cards, window displays, lantern slides, and booklets on their various products.

New Plant of the Willard Storage Battery Co.

The New Plant of the Willard Storage Battery Company, of Cleveland, Ohio, is building a large and thoroughly equipped battery, which is to occupy six acres of floor space, when completed will be the most modern and best equipped storage battery factory in existence. In the building of this factory, the Willard people are sparing no expense, and their 20 years' experience in battery manufacture, has enabled them to determine the best arrangement for buildings, equipment, etc. Ground was broken on the 24th of September, and work is progressing rapidly. Several of the buildings will be under cover before the snow flies.

In order to take care of the heavy contracts for 1915 both the new and old factories will be operated during the first months of 1915, under a plan that will enable the company to go right on with their immense output without interruption. As each building in the new plant is finished, it will be equipped with machinery which is the duplicate of that used in the same department at the old factory. The new machinery will be in operation before removing any of the old machinery, so there will be no delay in any of the departments.

The Railroad Facilities at this new plant are ideal. A belt line connecting with all railroads in the city, borders two sides of the site and the company will have their own switch engine to accommodate 25 cars.

In addition to the factory buildings, there will be an administration building 2 stories high.

RAILWAY
ELECTRICAL ENGINEER
Official Journal
of the Association of Railway Electrical Engineers.
PUBLISHED MONTHLY BY
WRAY PUBLISHING CO.
EDWARD WRAY,
President.
C. D. SPERRY.
Assoc. Editor.
ADVERTISING BLDG.—123 W. MADISON ST.
CHICAGO.
Telephone, Randolph 7414.

Entered as second-class matter, August 6, 1909, at the Post Office at Chicago, Ill., under the Act of March 3, 1879.

TERMS OF SUBSCRIPTION
United States, Canada and Mexico - - - Per Year, $1.00
Foreign - - - - - - - - - - Per Year, $1.50

Table of Contents

Page

Editorials:

Why Don't More Roads Electrify....................275
The Importance of Good Lighting in Railroad Service...275
Electric Towing System for Panama Canal Locks..........276
Some Results of the New Haven Electrification.........279
Westinghouse Exhibit at the Panama Pacific Exposition.....281
Railroad Electricians' Club..............................282

Shop Motor Section

Synchronizing A. C. Machinery, by J. H. Wickman......284
Principles of A. C. Machinery, by Willard Doud........287

A. B. C. Car Lighting Course, Lesson No. 37

Safety Type "F" Equipment, Continued................290
Practical Stunts 295
Mr. E. Wanamaker 297
With the Manufacturers 298
Association Director 300

Why Don't More Roads Electrfy?

This question is frequently asked by laymen. They argue that if greater economies can be affected by electrifying steam railroads, then the sooner that this is brought about the better it will be for all concerned. Mr. Murry, consulting engineer of the New Haven road, answers this question and gives a very careful analysis of the situation in his article found elsewhere in this issue.

It would be most impractical for any railroad to attempt a general electrification for the reason that a great deal of still useful equipment would be withdrawn from service. By proceeding slowly a railroad is able to use the steam equipment removed from an electrified division on other divisions still using steam thus reducing the steam equipment gradually.

The public often becomes impatient and demands tunnel and terminal electrification without stopping to consider the significance of what they ask. Electrification of this sort calls for the greatest outlay of capital and gives the smallest return on the money invested. If unwise legislation forces railroads into such unprofitable undertakings the result will be that capital will become skeptical of the economy of general electrification and the very thing that legislation is trying to encourage will be defeated. The proper solution to this problem is to wait until the terminal can be electrified as part of an engine division.

Economy also demands that the railroads remain conservative for in order that a railroad may earn the greatest profit after being electrified it is necessary for the men in charge to have had an electrical training. By a gradual scheme of electrification the younger men can direct their attention to problems of electrical operation and the engineers now in service will not be forced to become electrical engineers.

There will probably not be any extensive electrifications planned until financial conditions become somewhat improved, for large sums of money are needed to buy substations, line materials and locomotives.

The Importance of Good Lighting in Railroad Service

The electrical departments of the various railroads have, as a rule, been very progressive for many years in obtaining adequate and proper illumination of railroad cars, stations, yards, shops, etc. In this, however, they have not always had the co-operation of the management higher up, chiefly on account of the financial considerations involved. A greater appreciation on the part of these officials, however, of the necessity and actual dividend paying value of good illumination is making the work of the chief electrician more effective in producing good results.

The recent development of the type "C" mazda has also been a very important factor, for now it is possible to economically light large areas, such as classification, storage and freight yards and large areas in and about railroad shops, roundhouses, terminals, etc. In the classification yard, the dividend paying value of good lighting is most apparent, for this yard is, in a way, the center of the entire freight handling system. All freight must pass through this yard and a tie-up or low efficiency in handling freight at this point will mean a tie-up or low efficiency for the entire division.

Since over 50% of the classification is done at night the importance of an adequate system of illumination whereby the foreman on the hump can see every car rider in the yards, is at once evident.

By using angle type reflectors mounted in a row on each side of the classification yard, which direct the light toward the center of the yard and away from the hump, all tracks are adequately illuminated and the eyes of the car rider are completely protected from the glare of high candle power lamps. Incidentally, a properly lighted classification yard greatly reduces the death toll among car riders, which, in some yards, amounts to nearly one man per week.

Another evidence of an appreciation of good lighting conditions by the railroads is that many roads now have a gang of a few men at each terminal whose sole job is to keep the lighting units clean. They take care of not only lights in terminal stations, but also in yards, shops, freight houses, elevators, etc.

There is probably no class of service in which the depreciation of lighting efficiency is so great as that on railroads, but when one considers the magnitude of railroad lighting installations in the aggregate, even this indication of an appreciation of what constitutes good lighting is encouraging. As the influence of the recent freight rate advance loosens up the railroad financial market, many of the classification yards and other areas about railroad shops, terminals, etc., at present either inadequately lighted or not lighted at all, will undoubtedly be provided with a modern installation of type "C" lamps with proper reflecting units.

Electric Towing System for Panama Canal Locks

The President of the United States in June, 1905, appointed a Board of Consulting Engineers, men of international reputation, "for the purpose of considering the various plans proposed to and by the Isthmian Canal Commission for the construction of a canal across the Isthmus of Panama."

The majority report of this Board of Consulting Engineers contains the following:

"The three accidents at St. Mary's Falls Canal occurred within a period of nine years, where there is only one lockage of about 20 feet. If six locks should be adopted in a plan for the Panama Canal, each having a lift of 30 feet or more, as has been proposed in several projects, it would not be unreasonable, with an equal number of vessels, to look for six times the number of accidents in the same period of time, which would be at the rate of two per year. If groups of locks should be arranged in flights, as has also been proposed in some projects, the imminence of disastrous accidents would be greatly enhanced, as would be the amount of damage to the structures and to the vessels involved, it is highly probable that the grave disaster of a great ocean steamship breaking through the gates of the upper lock and plunging down through those below might be realized."

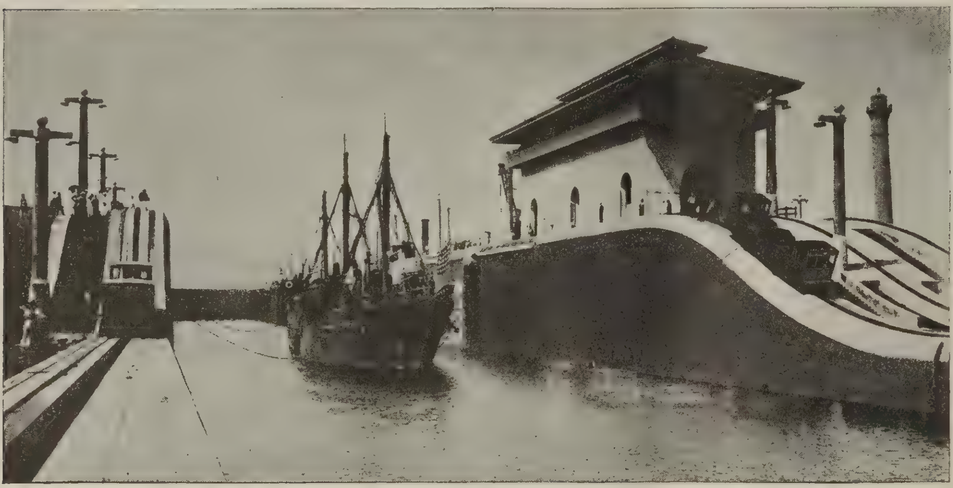


Fig. 1. Operation of Gatun Locks. S. S. "Severn" Leaving Upper East Chamber in Tow of Electric Locomotives.

It is true that the majority of the Board favored the adoption of the sea level canal; but the foregoing quotation showed the necessity, in their opinion, of safeguarding the passage of vessels through the locks.

Various systems are in vogue at dry docks, to pass ships through the locks. The employment of winches, or capstans, has been looked upon with a great deal of favor. These are usually placed at intervals along the dock walls, and the lines from the ship are carried forward to the successive capstans as the ship advances. Such a system involves the risk of the ship not being properly safeguarded when the lines are transferred to successive capstans. An improvement has been made by the installation of a capstan at the head of the dock, centrally located, and used for imparting a straight motion to the ship. Numerous lines from the ship to the dock wall are carried by men; and the capstans are employed to counteract any wind pressure, currents, etc., and assist generally in maneuvering the ship. While an improvement over former methods, it did not, however, possess the flexibility and reliability required for the operation of the locks of the Panama Canal. Neither would it have eliminated the breaking of the lines at critical moments, which is regarded as one of the essential requirements in successfully handling ships in canal locks.

After a very thorough study of the entire problem of maneuvering ships through the locks of the Canal, it became evident that they should not proceed through the locks under their own power, and that a substitute for the ship's power should embrace the following requirements:

(a) Ability to place the ship in proper relation to the lock.

(b) Capability of keeping the ship to its course.

(c) Accelerating and retarding the ship without rupturing the lines.

(d) The lines when once attached should be used without change for lockage in flight.

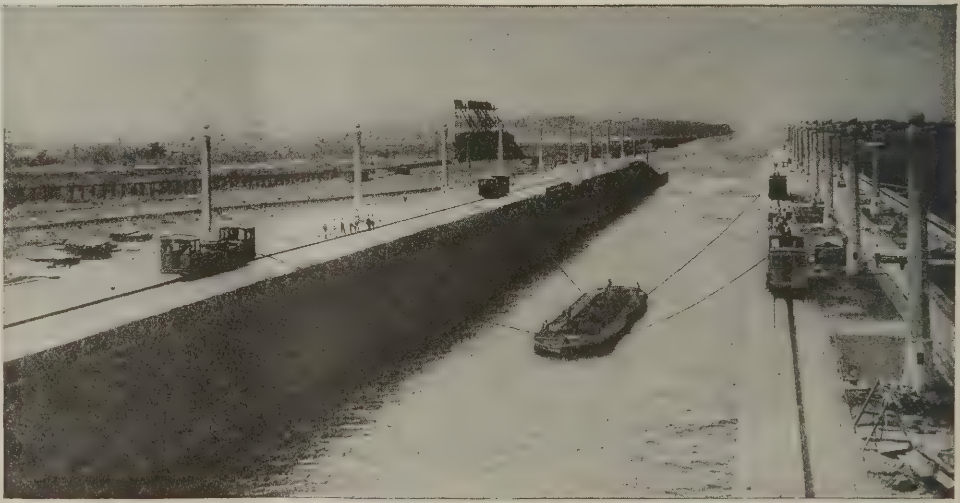


Fig. 2. Towing Locomotives on First Trial Run, Returning Barge Through Gatun Locks to Atlantic Level.

(e) A small number of skilled operators rather than a large number of unskilled men to co-ordinate.

The towing system described in the following pages was designed and patented by Mr. Edward Schildhauer, Electrical and Mechanical Engineer of the Isthmian Canal Commission; and the forty towing locomotives and all the electrical apparatus for operating the locks were built by the General Electric Company.

Towing System

In passing through the Canal from the Atlantic to the Pacific, a vessel will enter the approach channel in Limon Bay, which extends to Gatun, a distance of about 7 miles. At Gatun it will enter a series of three locks in flight and be raised 85 feet to the level of Gatun Lake. It may then steam at full speed through the channel in this lake, for a distance of 24 miles, to Bas Obispo, where it will enter the Culebra Cut. It will pass through this cut, which has a length of nine miles, and reach Pedro Miguel, where it will enter a lock and be lowered 30 feet. Then it will pass through Miraflores Lake for a distance of 1½ miles until it reaches Miraflores, where it will be lowered 55 feet through two locks, to the sea level, after which it passes out into the Pacific through an 8½-mile channel.

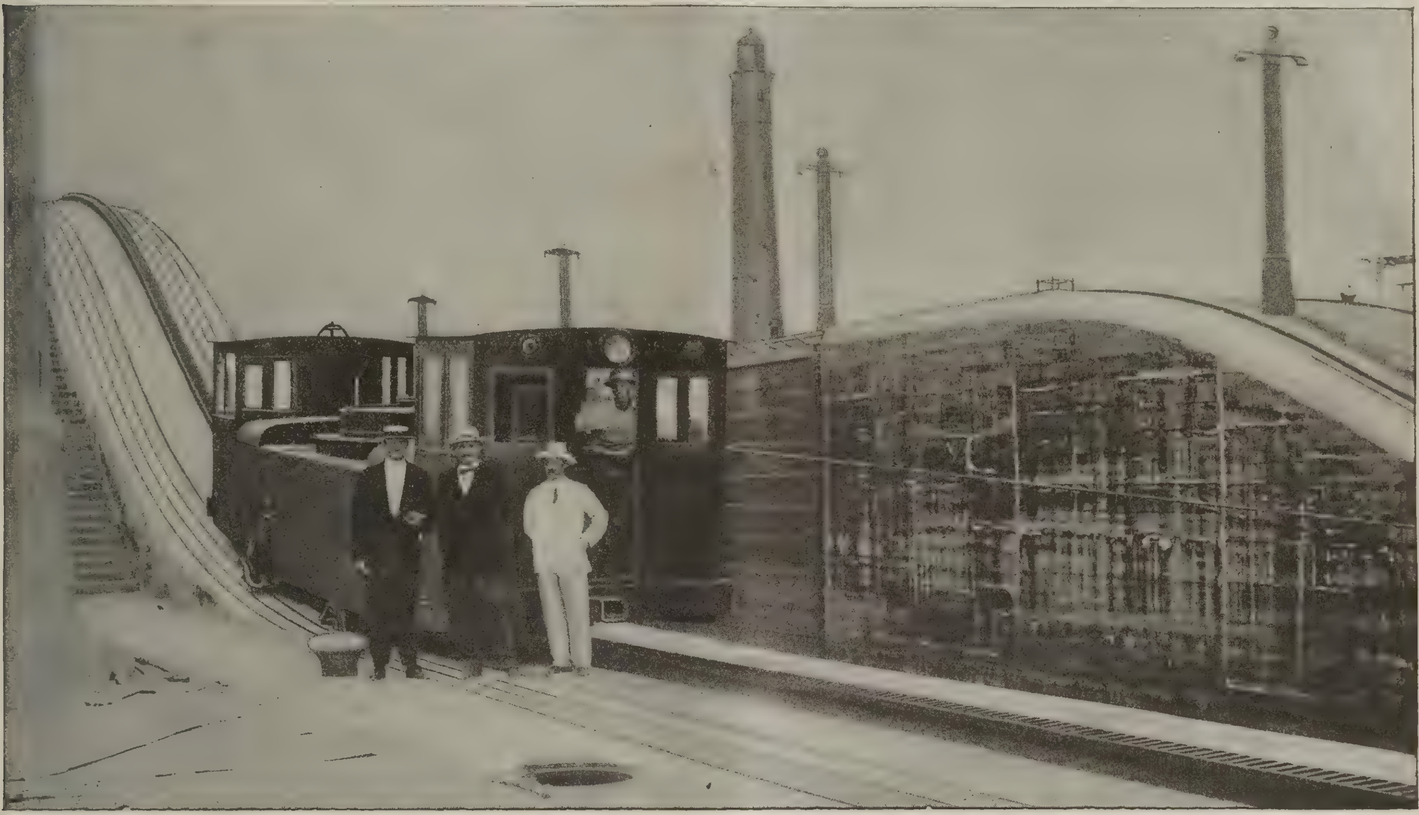


Fig. 3. Towing Locomotive About to Ascend the Incline Leading to the Top Level of Gatun Locks.

The main features of all the lock sites are identical; and the following brief description of the Gatun Locks, with special reference to the arrangement of the towing tracks, ship channels, inclines and approaches, is given to enable the reader to obtain a clearer conception of the towing scheme in general, as well as the more detailed description of the locomotive which is to follow.

The ship channels for traffic in each direction are separated by a center wall, the total length of which is 6,330 feet. There are two systems of tracks, one for towing and the other for the return of the locomotives when returning idle. This, however, refers only to the outer walls. For the center wall, there is only one return track in common for both the towing tracks. The towing tracks are naturally placed next to the channel side, and the system of towing utilizes normally not less than four locomotives running along the lock walls. Two of them are opposite each other in advance of the vessel, and two run opposite each other following the vessel, as seen in Fig. 5. The number of locomotives is, however, increased when the tonnage of the ship demands it.

Cables extend from the forward locomotives and connect with the port and starboard sides respectively of the vessel near the bow, and other cables connect the rear locomotives with the port and starboard quarters of the vessel. The lengths of the various cables are adjusted by a special winding drum on the locomotive to place the vessel substantially in mid-channel. When the leading locomotives are started, they will tow the vessel; while the trailing locomotives will follow and keep all the cables taut. By changing the lengths of the rear cables, the vessel can be guided; and to stop the vessel, all the loco-

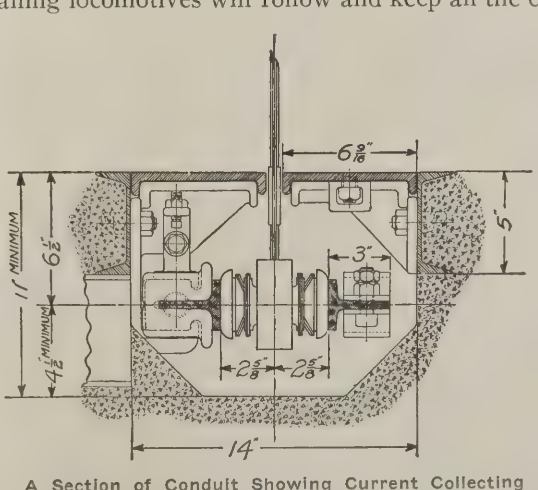


Fig. 4. A Section of Conduit Showing Current Collecting Device for Two Phases and the Underground Tee Rails From Which the Current Is Taken. Traction Rails Form Third Wire of the Circuit.

motives are slowed down and stopped, thus bringing the rear locomotives in action to retard the ship. Therefore, the vessel is always under complete control quite independent of its own power, and the danger of injury to the lock walls and gates is very greatly lessened.

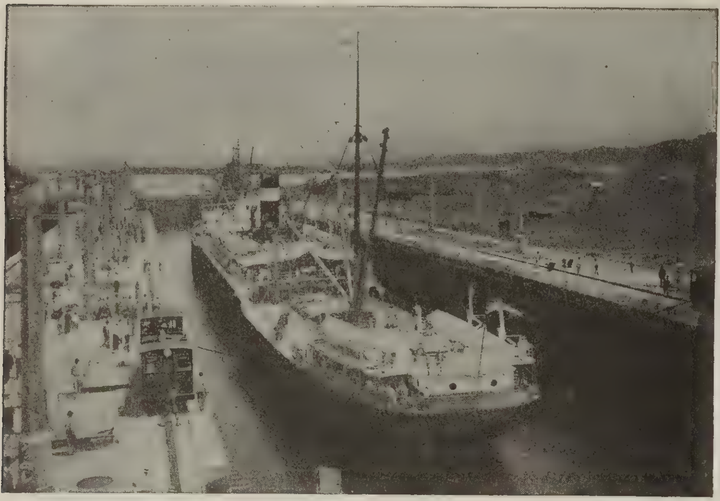


Fig. 5. Operation of Gatun Locks, S. S. "Anchon" Entering Upper Locks From Middle West Chamber Under Tow of Electric Locomotives.

The illustration in Fig. 2 shows how effectively the four locomotives keep the vessel under control and in the center of the channel, while Figs. 1 to 5 give a general idea of the method of handling vessels of various sizes. They also show general views of the lock walls, towing tracks and the inclines, the steepness of the latter being especially noticeable. Of particular interest is Fig. 2, which represents a trial tow approaching the second level. The water in the middle lock or at this second level is at sea-level, a condition not obtained in regular operation, and this trial was made to demonstrate that the tow lines would clear the lock walls.

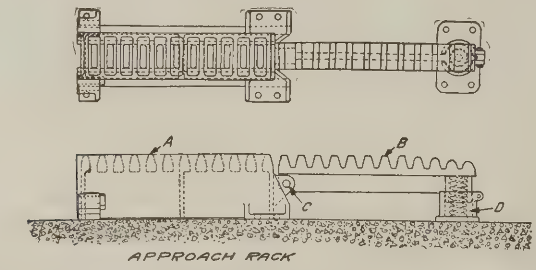


Fig. 6. A Section of the Fixed Rack-Rail at the Left to Which a Section of Movable Rail-Track Is Hinged at "C". One of These Movable Sections Is Located at Each End of the Rack-Rail. An Approaching Train Compresses the Spring "D" Until Gears Mesh.

The towing tracks have a specially designed rack rail extending the entire length of the track and located centrally with respect to the running rails. It is through this rack rail that the locomotive exerts the traction necessary for propelling large ships and climbing the steep inclines.

A rack rail is also provided on short portions of the return track so as to lower the locomotives safely from one level to the next. The steepest slope is 26 degrees or 44 per cent, hence the need will be seen for rack rail even on the return track, it being noted that any traction locomotive with the usual wheel drive, even with the brakes set, would begin to slide on a 16 per cent grade and therefore could not be controlled. With a rack rail, however, traction is limited only by the capacity of the driving motors and not by the adhesion of the wheel treads on the rails.

A small portion of rack rail is shown in Fig. 6, "A" being the rack rail proper and "B" the approach to it. "B" is hinged at "C" so that it can be depressed on the approach of the rack pinion of the locomotive. The teeth of the approach section are under size and shaped off at the extreme end so that the teeth of the pinion will mesh properly and prevent excessive strain on the pinion and the axle. The spring "D" restores the approach to the proper position after the locomotive has passed over. The rack rail is of the shrouded type, and each tooth space has a drain hole cast in the bottom so as to carry off water and other accumulations to suitable drain pipes or ducts set in the concrete of the walls. A further feature of the rack rail is the projecting edges, which permit thrust wheels attached to the locomotive to run along the under side and prevent overturning of the locomotive, in case some unforeseen operating condition should produce an excessive pull on the towline. These thrust wheels serve to counteract the lateral component of the towline pull and the flanges act for emergency only, as the weight of the locomotive is, however, sufficient to prevent overturning with a normal pull of 25,000 pounds on the towline.

Three-phase, 25-cycle, 220-volt alternating current is used for operating the locomotives, and the current is supplied to the locomotives through an underground contact system. Two T-rails (shown in black section) form two legs of the three-phase circuit and the third leg is formed by the main track rails. A specially designed contact plow slides between the two "T" conductors and transmits the power from the rails to the locomotive. This contact plow also passes through the slot opening in the conduit cover and is flexibly connected to the locomotive in such a manner as to follow all irregularities in the tracks and crossovers, and therefore insures a continuous supply of power. See Fig. 4.

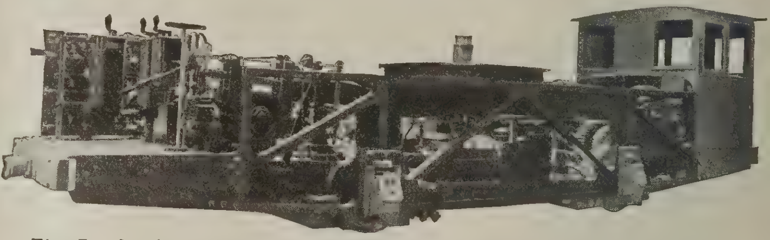


Fig. 7. A View of the Locomotive With Covers and One Cab Removed Showing the Controllers and Front of One Control Panel.

The design of the locomotives was described in the Railway Electrical Engineer in May, 1914, so it will not be gone into in detail at this time. One of the additional features that it is well to mention at this time is the solenoid brakes. When the power from the motors is turned off the solenoid operating the brakes is automatically energized. The first point on the controller releases the brakes so a coasting point is provided. This magnetic brake control is supplemented by a manually operated control acting through the same set of levers. These brakes will stop the car in two rotations of the car wheels.

During the first three months of commercial operation of the Canal, from August 15 to November 15, the cargo transported through the Canal and towed through the locks by the locomotives amounted to 1,079,521 tons. During the fiscal year ending June 30, 1914, the Panama railroad carried 643,178 tons of through freight between the two seaboards, and in the preceding fiscal year 594,040 tons. From this it is seen that between six and seven times as much cargo is passing over the Isthmus now as passed over this route when goods were transshipped by rail.

Some Results of the New Haven Electrification

At a joint meeting of the Franklin Institute and the Philadelphia section of the American Institute of Electrical Engineers, held in Philadelphia on January 20th, William S. Murray, consulting engineer of the N. Y., N. H. & H. Railroad, delivered a paper entitled "Conditions Affecting Success of Main Line Electrification." The audience which heard this address was a large one and the paper was discussed by several prominent steam railroad officials.

In treating this subject, Mr. Murray first dealt with the historical development of the electrification of steam roads. He pointed to the fact that after steam railroad electrification had made considerable progress a period of inactivity followed. This was due, in part, to attempts which were made to force railroads to electrify to do away with the smoke nuisance. This added financial burden caused them to cease in their work and for a long period railroads did not extend their mileage of electrified lines. This gave them ample time to look into the characteristics and advantages of the different systems then in vogue and to profit by the mistakes that had been made on roads already in operation.

Mr. Murray then discussed the reasons that lead up to the adoption of the present system on the New Haven road. In discussing the general principles of successful electrification he compared the relative merits of the electric and steam locomotive. Most of the data on the operation of the New Haven road was given in tabular form, some of which is here reproduced.

Traffic on the New Haven.

In discussing traffic conditions on the New Haven road, Mr. Murray stated that the present schedule calls for a total of 210 daily trains, 114 of which are handled by electric locomotives, the remainder being multiple unit equipment. On every day but Sunday 68 trains run into the grand terminal. Besides this, there are two through trains out of the Harlem River station. Corresponding to each of these trains there is one running in the opposite direction, which makes 140 trains a day. The New Cannan branch has in daily operation 16 trains each way between Stamford and New Cannan, and on the Harlem River branch between New Rochelle and Harlem River 19 trains run each way on week days and a special on Sunday. Electric locomotives handle 36 of the 72 trains the entire distance, the remaining 34 being operated by steam between New Haven and Stamford.

There are 48 a.c.-d.c. locomotives used in passenger service and 4 a.c. motor cars and 21 a.c.-d.c. motor cars and 46 trailers used as multiple equipment. There are 100 electric locomotives for passenger, freight and switching service and 69 multiple unit cars, all of which are maintained in one repair shop, although inspection is made at several different points. Many of the new locomotives are equipped with flash boilers to provide for steam heating of the through trains between New York and New Haven.

The passenger locomotives cover 6,200 miles a day, some single engines making as much as 500 miles, multiple unit cars having on an average 2 trailers aggregate 2,100 miles a day. Only one trailer is used on the New Cannan branch, while on the Harlem branch the half use one trailer and the rest two trailers.

The traffic on this road during the year 1913 amounted to 2,182,000 electric locomotive miles, or 600,000,000 ton miles. This is based on 73 miles of electrified line, 61 miles of which is four-track, and 12 miles six-track line. The single-track equivalent of this is 316 miles, and counting in the 184 miles of yards, sidings and spurs, the total equivalent single-track mileage is 500. At present a single power station at Cos Cob supplies the electric power; very soon, however, power will be available at the eastern and western ends of the electrified zone.

Table of Equipment Failures

	Classes of Service							
	Passenger		Freight		Switch		Multiple	
	Nov.	Oct.	Nov.	Oct.	Nov.	Oct.	Nov.	Oct.
Heated parts...	1	4	1	2	....	....	3	....
Broken parts...	2	1	1	2	....	....	2	1
Grounds	20	25	3	2	....	....	2	....
Miscellaneous ..	12	6		1	....	....	11	11
Total failures...	35	36	5	7	....	....	18	12
Miles per failure	7,071	7,328	13,183	9,506	40,964	39,624	3,554	4,331
Minutes detention per failure	11	13	56	60	....	....	18	7

Table of Line and Equipment Failures

	November		October	
	No. of Failures	Total Delay, Min.	No. of Failures	Total Delay, Min.
Type of failure:				
Catenary insulator	3	22	1	14
Dead end	3	...	1	....
Other line failures..........	7	61	10	62
Equipment	10	169	7	166
Signal	1	15	1	....
Outside interference	4	....	3	....
Employee	1	....	....	....
Totals	29	267	23	242

The total cost of the electrification has been in the neighborhood of $15,000,000. A credit should be made, however, of the value of 150 steam locomotives that have been transferred to other parts of the system. Likewise, the steel bodies for the multiple unit cars would have been purchased notwithstanding the electrification, and several other items of this nature might somewhat reduce the total amount.

Economy of Electrification.

The economies that are possible through electrification are primarily dependent upon the density of traffic over the section to be electrified. It cannot be said that an electrification would be practical on one road for the reason that it is on another, because traffic conditions are not the same on all roads. For if they were, it would be a simple matter to plot two intersecting curves, one representing the saving to be made by changing from steam to electricity, and the other, the annual cost of interest, depreciation, maintenance, insurance and taxes on the electric power plants, including all such equipment as power houses, lines and shops. Unfortunately, the analysis is not as simple as this, for even if two railroads were carrying the same number of tons and per mile on an average, local conditions might so vary the general results that the results obtained would be incorrect.

In speaking of the cost of power, it was asserted that the energy resulting from burning a pound of coal in the boiler of the central station when transmitted to the electric locomotive will develop twice the draw-bar pull at the same speed that will result from burning a pound of coal in a steam locomotive. But fuel is only one item of many to be taken into consideration.

CONDENSED TABLE OF ENERGY DATA

	November		October	
	Total	Per Kw-hr.	Total	Per Kw-hr.
Coal consumed	12,439 tons	2.78 lb.	12,281 tons	2.75 lb.
Water consumed (gallons)	38,778,000	4.33	35,835,000	4.01
Cost of coal	$34,084	0.381 cent	$33,527	0.375 cent
Cost of water	$1,582	0.017 cent	$5,016	0.057 cent
Cost of other supplies	$317	0.004 cent	$656	0.007 cent
Maintenance of power plant and machinery	$3,655	0.041 cent	$3,434	0.038 cent
Wages and salaries	$6,057	0.068 cent	$6,704	0.075 cent
Total cost, maintenance and operation	$45,695	0.511 cent	$49,337	0.552 cent
Fixed charges (interest, taxes and insurance)	$16,107	0.180 cent	$16,107	0.180 cent
Total cost	$61,802	0.691 cent	$65,444	0.732 cent
Energy consumption (kw-hr.)				
Passenger service (electric locomotives)	2,894,465	......	3,072,145	......
Passenger service (multiple unit cars)	630,039	......	499,367	......
Freight service	1,508,306	......	1,494,082	......
Switching service	984,255	......	848,613	......
Non-revenue service	10,340	......	6,191	......
Total used by electric locomotives and motor cars	6,027,405	......	5,920,398	......
Signals	107,465	......	117,445	......
Other company purposes	389,652	......	399,401	......
Line loss	543,235	......	617,804	......
Total used for company purposes	7,067,757	......	7,055,048	......
New York, Westchester & Boston Railway	676,144	......	636,058	......
Other companies	1,205,699	......	1,255,139	......
Total energy used	8,949,600	......	8,946,245	......
Maximum daily output	Tuesday, Nov. 24 343,300 kw-hr.		Friday, Oct. 30 316,630 kw-hr.	
Maximum swing	Friday, Nov. 6—7 p.m. 30,000 kw		Sunday, Oct. 4—8.27 a.m. 29,800 kw	
Minimum daily output	Tuesday, Nov. 3 249,800 kw-hr.		Sunday, Oct. 18 256,155 kw-hr.	
Average daily output	301,902 kw-hr.		288,589 kw-hr.	
Energy Purchased from New York Central:				
Energy purchased (kw-hr.)	1,244,021	......	1,306,017	......
Cost of power	$16,097.67	......	$16,348.47	......
Cost per kw-hr. (cents)	1.294	......	1.252	......
Total Energy				
Total energy consumed (kw-hr.)	10,193,621	......	10,252,262	......
Total cost of power (including fixed charges)	$77,899.87	......	$81,792.32	......
Cost per kw-hr. (cent), including fixed charges	0.764	......	0.798	......

The New Haven railroad retained all its old steam locomotive engineers to operates its electric locomotives. That these men understand roadbed conditions and signals much better than any one else cannot be doubted, but it is hard for them to realize that they are not operating a steam locomotive and without electrical experience as they are, the electric locomotive is at a disadvantage under such conditions. It is essential that electrical trained men be used if the electrification makes its greatest success.

The whole problem of administration is different when electricity is used. Although the electric locomotive is continually increasing in ruggedness, it probably will never be as fool-proof as the modern steam locomotive.

Under the most favorable conditions the expense due to maintenance and repairs of the electric locomotive can be reduced to one-half that of the steam locomotive. By the nature of the two, however, the electric locomotive requires constant inspection and attention and cannot be treated like the steam locomotive, for if it were its repair expense would be very much greater than the latter. Steam engineers would notice with satisfaction that the electric locomotive would pull twice the load for which it was designed and then be surprised when it would fail shortly afterwards while operating at half capacity.

Cost of Operation.

The conditions met with on the New Haven electrification required the use of both alternating and direct current. This handicapped the electrical plant from the start, and the shop facilities were not great enough to take care of the heavy repairs that had been made necessary throughout the entire system. The fact that the repairs to electric passenger locomotives cost 8.56c per locomotive-mile last October and 10.61c in November is explained by the fact that during November the passenger engines were being given a general overhauling. Many of the electrical locomotives had not been overhauled since 1907 and have made during this time some 350,000 miles.

The table of passenger engine operating costs given below shows the lack of maintenance which the electric locomotives suffered in the earlier days of operation. The first 10 locomotives of the a.c.-d.c. type to be overhauled have on record to their credit an average cost of less than 5c per locomotive mile. If conditions had permitted the engines to be designed for straight a.c. service, Mr. Murray did not doubt that the cost would be reduced to 4c per locomotive-mile. The power rate for different classes of passenger service varies according to the number of stops per mile. The energy consumption of the various trains may be seen by consulting the following table:

TABLE OF PASSENGER AND FREIGHT OPERATING COSTS

	Locomotive repairs		Power		Locomotive supplies		Engine house expenses		Enginemen		Trainmen		Total	
Passenger trains hauled by locomotives:	November	October	November	October	November	October	November	October	November	October	November	October	November	October
Cost per train-mile (cents)	17.15	13.80	19.33	19.89	2.23	1.53	0.57	0.54	8.81	8.37	9.51	9.55	57.60	53.68
Cost per locomotive-mile (cents)	10.61	8.56	11.96	12.29	1.39	0.95	0.38	0.34	5.41	5.20	5.88	5.91	35.63	33.25
Cost per car-mile (cents)	2.45	1.93	2.76	2.79	0.32	0.21	0.08	0.08	1.26	1.17	1.36	1.34	8.23	7.52
Multiple unit trains:														
Cost per train-mile (cents)	15.27	11.83	11.39	11.42	0.24	0.16	0.91	0.78	5.17	5.20	8.84	7.53	41.82	36.92
Cost per motor-car-mile (cents)	10.51	7.98	7.84	7.70	0.17	0.11	0.62	0.53	3.56	3.51	6.08	5.08	28.78	24.91
Cost per car-mile (cents)	4.32	3.12	3.22	3.01	0.07	0.04	0.25	0.21	1.46	1.37	2.52	1.98	11.84	9.73
Freight trains hauled by locomotives:														
Cost per train-mile (cents)	15.51	15.98	28.51	27.90	0.54	0.63	0.48	0.58	10.66	10.44	17.83	17.46	73.53	72.99
Cost per locomotive-mile (cents)	9.69	10.19	17.82	17.79	0.34	0.40	0.30	0.37	6.67	6.66	11.14	11.13	45.96	46.54
Cost per 1000-ton-mile (cents)	9.95	10.16	18.30	17.73	0.35	0.40	0.31	0.37	6.84	6.63	11.45	11.09	47.20	46.38

	Watt-Hours per Ton-Mile Eastbound	Westbound
New Haven Express	31.4	32.0
Stamford Express	34.2	40.3
Stamford local	59.0	63.7
Port Chester	66.7	77.3
New Rochelle	90.2	—
Average	42.2	47.4
Average values for all freight trains	32.8	33

If allowance is made in freight service for the weight of the electric locomotive, the rate is reduced to 26 watt-hours per ton-mile, 30 watt-hours is a reliable figure to cover electric freight operation on level track in a combination of fast and slow service.

Cost of Equipment.

A first class high speed 100-ton straight a.c. electric passenger locomotive for handling a 250-ton trailing load in normal suburban service should cost about $40,000. The cost of a steam locomotive for similar service would be $15,000. The capital investment necessary to cover the cost of electric power house and transmission equipment necessary to supply one such electric locomotive with current would be about another $40,000. Under present conditions of labor and cost of material, the cost of locomotive weighing about 100 tons varies between 18 and 20 cents a pound. When figured on the pound basis, the cost of all locomotives of this weight for all classes of service is about the same, whether it is made for high speed or switching service. The cost per pound of multiple unit cars, which are now usually built of steel, does not vary considerably from this, being slightly higher, if anything.

The cost per mile of 6-track catenary construction of the compound type (with auxiliary messenger wire) in 300-ft. spans is $38,760 for tangent tracks, $43,000 where the curvature is less than 1 degree, and $59,230 for curvature between 1 and 4 degrees. The cost of 4-track construction is $25,490 for the tangent track and $27,550 to $40,940 for the curved track. Likewise, the 2-track construction is $19,190 and $21,610 to $24,960, but when the curvature is over 4 degrees a pull-off pole is needed and the cost per mile is $34,450. The cost of 2-track single catenary is $13,720 for tangent track and curves up to 2½ degrees; $15,110 to 3½ degrees and 260-ft. span; $19,385 up to 4½ degrees with a pull-off pole and 200 ft. span.

The total cost of anchor and sectionalizing bridge, including steel, concrete floor on upper deck of bridge, control apparatus and connections and sectionalizing are as follows: Compound catenary, six-track, $14,000; four-track, $9,730; two-track, $6,660, and for single cantenary four-track, $9,020; two-track, $6,120.

According to Mr. Murray, further electrification cannot be considered until a healthy condition of finances is brought about in this country. Partial electrification for yards and terminals only is a heavy burden for the railroads to carry, for in this class of service the maximum cost is combined with a minimum direct return upon the capital invested.

Diesel-Electric Car.

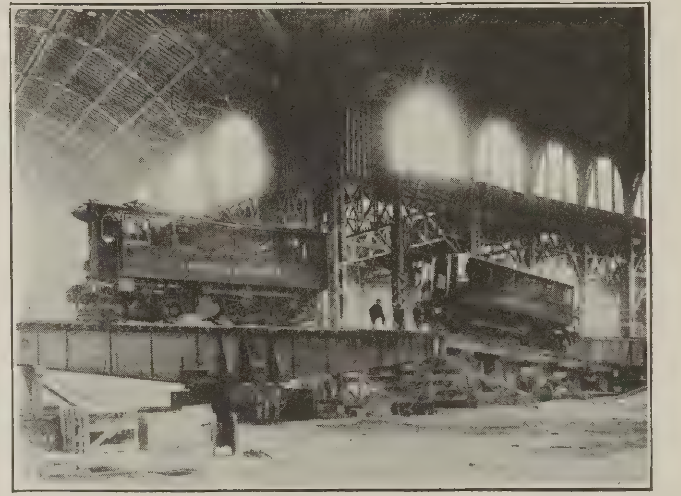
A Diesel-Electric car, similar to the gas-electric car, is being successfully operated between Rastatt and Gernsack, in Saxon, Germany. The Diesel engine has a capacity of 147 kw. and operates at 450 r. p. m., with control apparatus reducing the speed to 200 r. p. m. The engine has six cylinders and operates on the four cycle principle. At a speed of 45 miles per hour the operation is quiet and the vibration not troublesome. Jour. of Electricity.

Westinghouse Exhibit at Panama Exposition

One of the most striking exhibits to be made at the Panama-Pacific Exposition will undoubtedly be that of the Westinghouse Electric & Manufacturing Company, which includes one of the Pennsylvania Railroad locomotives mounted on a turn table.

The location of the turn table is under the center of the dome of the immense Transportation Building at the junction of the two main aisles, thus bringing it in full view of crowds which are expected to pass through this building, which will contain a large number of exhibits of great interest to the public at large.

The turn table is 65 feet long, and weighs 440,000 pounds, including the locomotive. The height of the track is 12 feet above the floor, and steel ties are used, a new type of construction for this class of work.



View of Double Unit Electric Locomotive Being Put in Place on the Turntable Upon Which It Will Rest During the Exhibition.

By means of 10 horsepower, 3-phase, 220-volt motor the turn table is caused to revolve at a speed of once in three minutes, thus giving the crowds in each end of the building different views of the locomotive. The rotation, which can be reversed in direction, is under the control of the operator located in a booth near by

A decidedly unique method of collecting the current for lighting the locomotive is employed. This was designed by the Westinghouse engineers and involves bringing the leads up through center bearing, to collector rings, thus obviating the use of third rail shoes or trolleys. The locomotive is arranged and lighted so as to permit the people to pass through it and inspect the equipment.

This locomotive is said to be the largest in the world in passenger service. It consists of two units and weighs 156 tons, and is the first side-rod gearless locomotive ever placed in service. It is equipped with two motors having a total capacity of 4000 horsepower, and Westinghouse unit switch control equipment of the HBF type, which has made the phenomenal record of 99,549 miles per train minute delay power control failure. Twelve million passengers annually are transported over the electrified terminal of the Pennsylvania Railroad from Harrison, N. J., to Pennsylvania Station, New York City by these locomotives, which are capable of obtaining a speed of 60 miles per hour with full train.

A complete line of commutating-pole railway motors including box, and split frame types for various voltages from 600 to 1500 will also be shown, and in addition a preliminary sample of the new pressed steel railway motor.

The Railroad Electricians' Club

Meetings the 3rd Monday of Every Month, 8 P. M.—18th Floor Transportation Bldg., Harrison and Dearborn Sts., Chicago—Everybody Welcome—No Dues

Lead Storage Battery Questions

Remedy for Iron Impurity

Q. 83. What should be done with cells containing iron impurity?

Ans. 83. If it is found that much iron is present in the electrolyte after making the test as described in Prob. 82, published last month, the electrolyte must be thrown away and the plates rinsed off and new electrolyte added.

Reversal of One or More Cells in a Battery

Q. 84. What causes one or more cells in a battery to show reversed polarity?

Ans. 84. When one cell of a battery either gets a local short circuit between plates, due to contact with the sediment or to a lead tree formation between the plates, or because of iron impurity, as described in Prob.. 79, published last month, that particular cell is continuously discharged. This cell, on standing a few hours or possibly a day or two, may become completely discharged, while the other cells of the battery may be in a fully charged condition. Even if that cell is not completely discharged it will be in a much lower state of charge than the other cells of the battery, and when the lights are turned on and the whole battery discharged, this discharge current will soon exhaust the remaining capacity of that particular cell. When this occurs, the voltage across the terminals of that cell instead of being two volts or slighting over, like the other cells, will fall to zero. If the lamps are still on, the discharge current will continue flowing, however, and soon all of the lead sponge of the negative plates of this cell will have been oxidized and all of the peroxide of the positive plates will have been reduced by the action of the discharge current; both the positive and the negative plates have now become practically the same, both lead oxide, so for a very short time the cell will show zero voltage.

As the discharge current continues to flow, however, the oxidizing action at the negative plates and reducing action at the positive plates will also continue; that is, the negative plate will be further oxidized, forming lead peroxide, and the positive plate will be still further reduced, forming lead sponge. This is just the reverse of the active material of normal battery plates, so the lead peroxide on the negative plate, even though present only in a small quantity, will show a positive polarity, and the lead sponge on the positive plate will show a negative polarity. Thus the polarity of that particular cell becomes reversed and bucks down the voltage of the other cells of the battery.

One reversed cell in a battery will reduce the terminal voltage of that cell about 4 volts, for not only will the battery voltage be lowered by the loss of 2 volts generated by that cell, but the cell will generate another two volts in the reverse direction.

Detecting Overcharge

Q. 85. How can you tell when a battery is being seriously overcharged?

Ans. 85. The surest way to tell whether a storage battery is being chronically overcharged or not is to put an ampere hour meter in circuit for a few trips. Either the variable resistor, the duplex train, or the graphic ampere hour meters will give a correct record of the situation. Overcharging is indicated roughly by, (1) Battery requiring flushing more frequently than once in four or five months. When a battery requires flushing once every week or two it is unDoubtedly being seriously overcharged. Overcharging causes the battery to gas and gasing decomposes the water in the electrolyte. (2) The battery arriving at the terminal in a heated condition. (3) Serious overcharging usually causes rapid disintegration of the plates, which gives a thick sediment in the bottom of the tank in a short time. It also usually causes plante type plates to grow, although this is not the only cause of growing.

Formation of Plates

Q. 86. What is meant by forming of plates?

Ans. 86. By speaking of "forming" we may refer to either the formation of the active material in plante type plates by the manufacturer, or we may refer to the normal formation of the plates in service, wherein the reserved lead in the plates is gradually formed into lead sponge and peroxide by the action of the electric current.

Growth of Plates in Service

Q. 87. What causes the plates "to form and grow?"

Ans. 87. All plante type plates form and grow in service. This is a natural result of the flow of electric current, as explained in the previous problem. This growth, however, in normal batteries should be slight. Some impurities, such as acetic acid or chlorides, tend to make the reserve lead in the plates form into active material more rapidly than the active material is shed in normal operation of the battery. If any of the forming agent employed by the manufacturer in forming the plates is allowed to remain in the battery, this will cause excessive growth of the plates. Overcharging either at low rates or high rates also causes the plates to form and grow.

The active material of the plates, either sponge lead or peroxide, occupies a greater amount of space than did the reserve lead from which the active material is formed. Furthermore, the lead sulphate formed in both plates on discharge occupies more space than the same active material does after it has been converted into lead sponge and peroxide by charging current. In other words, there is a slight swelling action every time the plate is discharged. This increase in volume on discharge, together with the gradual formation of reserve lead into active material, which has a much larger volume than metallic lead, causes the plates to stretch and grow. This stretching action takes place almost altogether lengthwise of the ribs of the plate. Lead is so soft a metal and the active material formed adheres so strongly to the surface of the reserve lead that its change in volume causes the plate to be stretched. In some cases plates normally 10 in. long have been known to grow 2 in., making the plate 12 in. long.

Remedy for Badly Grown Plates

Q. 88. What should be done with a battery in which the plates have grown so long that the covers cannot be put in place?

Ans. 88. When plante plates have grown to such an extent that they begin to force off the battery jar covers, the plates should be removed from the tank and the bottoms sawed off to make the plates standard length. This is necessary only in severe cases of abnormal growth, and the conditions causing it, as mentioned in problem 87, should be remedied.

Causes of Buckling

Q. 89. What causes the plates to buckle?

Ans. 89. In plante type plates buckling may be caused by improper formation of the plate; if one side of the plate is formed more deeply or more thoroughly than the other. The changes in volume of the active material which occur in service, causing greater swelling on one side of the plate than on the other, will twist and bend the soft lead web of the plate, causing it to buckle out of shape.

Conditions of operation may also tend to cause buckling. For instance, if a battery has been charged and discharged at a very high rate, its ribs and the pores of the active material are very open. If the battery service is now changed so that the battery is discharged and charged at low rates, especially on charge, its plates are liable to buckle. A quantity of new peroxide will have been formed deep down near the reserve lead of the plate and this can easily fill the available space between the pores too full.

Sulphation is also a serious cause of buckling. For when the active material turns into the white lead sulphate its volume becomes extremely great and all the pores and spaces between the ribs of the plate are overcrowded with sulphated active material. This may cause plates to tie themselves almost into knots. As a general proposition, it may be said that anything which causes more than a normal change in volume in the active material deep down in the plate where it gets a good grip on the reserve lead, will cause the plate to buckle.

Result of Buckled Plates

Q. 90. What damage does buckling of plates cause and how should it be remedied?

Ans. 90. When plates become badly buckled they crowd the separators and in some cases break them, allowing the plates to become short circuited. If plates are found to be buckled when the battery is cleaned, and they usually are to a more or less degree, the groups of elements should be separated and each group placed in an air press with spacing blocks between plates. The air press will then straighten out all buckles.

Porcelain Spacing Blocks

Q. 91. What are the porcelain blocks on the four sides of the tank for?

Ans. 91. The porcelain blocks on all four sides and bottom of tank are placed there so as to insulate each tank from the other tanks in the cell, and from the ground or frame work of the car. If the tanks are not properly insulated, a current will flow from the tanks near the positive side of the circuit to other tanks nearer the negative side wherever such grounds occur and, as explained in previous problems, the tanks near the positive end of the circuit will become pitted, due to the forming action of the electric current flowing through the grounds.

Connectors

Q. 92. Why is it necessary to sweat the lead connector back over the rubber insulation of the connecting leads?

Ans. 92. There is a certain amount of acid spray which is given off by the battery when it gases. This spray is very fine particles of sulphuric acid electrolyte and after coming out of the battery settles on the tops of the cells. If the copper wire of the lead connector is not very carefully protected by the rubber insulation and the lead lug, this acid spray will attack the copper and corrode it, forming copper sulphate. For this reason, when the lead lugs are molded onto the ends of the copper wire connectors the wire is inserted in the mold so that the lug will be cast well up over the rubber insulation. In casting on these lugs the lugs should be cooled as quickly as possible, so that the hot lead will not have a chance to burn deep into the insulation.

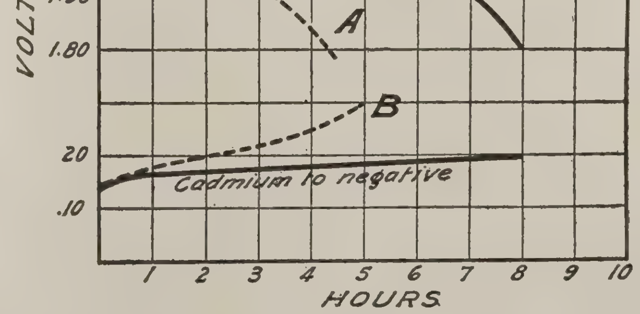
Hardening of Negatives

Q. 93. What is meant by hardening of negatives; how can you tell when the negatives of a cell have hardened and what should be done to remedy it?

Ans. 93. The negative plates of a storage battery do not usually have as hard service as the positives do and accordingly have an almost indefinite life. The negatives lose in capacity more or less after a few hundred cycles of charge and discharge, due to what is known as hardening of the negatives. This is caused by the grains of lead sponge gradually increasing in size and, of course, with the larger grains of negative material the total surface exposed to the electrolyte is less and the grains of lead sponge are not completely transformed into sulphate during the discharge.

As explained in a previous problem, when a battery shows low capacity this may be caused either by low capacity of positives or low capacity of the negatives, or both. An experienced battery man can tell by looking at the plates, which ones are in trouble, but the ordinary individual can only do so by testing with a cadmium electrode, reading the individual voltages of the positive and negative plates.

The solid lines of the accompanying curves showing



Curves Showing Voltage Between Cadmium Electrode and Positive and Negative Plates. Solid Lines Show Healthy Plates. If Either Plate is Low in Capacity its Curve Will be Something Like the Dotted Curves "A" or "B."

voltage on discharge between cadmium to positive and cadmium to negative indicate that both plates are in about normal condition. The dotted lines, however, show trouble in both cases. If the voltage between cadmium and negative rises to .3 of a volt after about five hours' discharge as shown on the accompanying curves, it indicates low capacity of the negatives and this is usually due to hardening of negatives. The remedy for this is to give the plates a normal rate, or, in severe cases, it may be necessary to remove the plates from the cells and give them the reversal treatment.

In this treatment the negatives are removed from the tanks and placed in another tank with lead sheet dummy plates. The negative plates are then connected to the positive charging line and the dummy plates to the negative charging line and the combination given a full charge.

The negative plates have now become charged as positives and the active material, instead of being lead sponge, is now lead peroxide.

The dummy plates should then be removed and new dummies inserted, so that any impurities such as copper which might have deposited on the negative plates and been transferred to the dummies in reversal, will not get back to the negatives. With the new dummies, the negatives are then connected to the negative charging line and the dummies to the positive line and current again forced through the combination until the peroxide of the negatives has all been reduced to lead sponge. This treatment will almost always be sufficient to bring the negatives back to full capacity.

Problems for Next Month

Lead Storage Battery Questions Continued.

Q. 94. What is meant by reserve lead in a plate?

Q. 95. Why do the rubber separators have holes?

Q. 96. What is the vent plug in the battery cover for?

How Car Lighting Batteries Are Made.

Q.—97. What is the main difference between the manufacture of pasted plates and plante type plates?

Q.—98. Which type of plate has been used most in railroad service, and why?

Q.—99. How is the Gould plante type plate made?

Q.—100. How is the Willard plante type plate made?

Q.—101. How is the U.S.L. plante type plate made?

Q.—102. How is active material formed in between the ribs of these plates?

Q.—103. What is the difference between forming a positive and forming a negative?

Q.—104. Why are the ribs made so that they taper from base to tip, being thick at the base deep down in the plate and thin at the outer edge of the rib at the surface of the plate?

Q.—105. Why isn't all of the lead in the ribs converted into active material? This would give the plate a much higher capacity.

Q.—106. Why is the number of negative plates in a cell always one more than the number of positive plates.

Q.—107. What are the advantages of rubber separators versus wooden separators?

Q.—108. Most wood contains a certain amount of acetic acid and as this injures the battery in service, it must be removed from the wood separators. What process is employed for removing the acid?

Q.—109. Why are rubber lining sheets placed on the inside of the lead battery tank on all sides of the plates?

Q.—110. Are these required with a stoneware jar or a hard rubber jar? Why?

Shop Motor Section

Synchronizing A. C. Machinery

J. W. Wickman

The fact that two sources of alternating current can be operated in parallel, providing that the voltage and frequency are the same, has for a long time been made use of in alternating current work. The wave forms of the generators operating in parallel should be the same, for if they are not, wattless current will flow between the machines which decreases the efficiency of the operation. However, in this article only the general principles involved in synchronizing two sources of alternating current will be considered.

To connect two sources of alternating current in parallel or lock them in synchronism, it is necessary to throw them together at an instant when their phase positions are the same, or in other words, when their maximum negative and positive values coincide and pass through their zero value at the same time. There are a number of ways of showing when two sources bear the proper phase relation to each other and several commercial methods of synchronizing will be discussed.

The most common alternating current systems in use at the present time are the two-phase and three-phase systems and all examples will deal with one or the other of these two systems. The synchronizing of two single phase machines is the same as connecting one phase of two polyphase machines in parallel so the same explanation will apply to single phase.

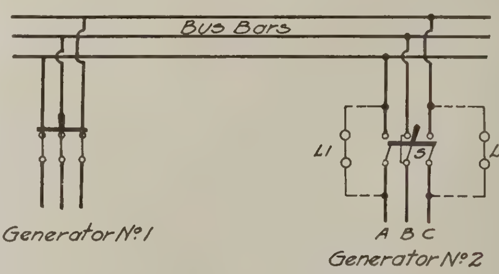


Fig. 1. Showing Connections for Synchronizing 220-Volt Three-Phase Generators; Switch "S" Is Shown When Lamps Are Dark.

In operating direct current machinery in parallel, all that is necessary is to have the two voltages approximately the same and then to connect the positive and negative leads of one source of energy to the corresponding leads of the other; the positive and negative leads being easily determined by the use of a voltmeter. However, with polyphase alternating current the leads of one machine must be connected to the corresponding leads of the incoming machine so that no one phase will be reversed. It is, however, much more difficult to find the phase relation of two alternating currents than it is to find the positive and negative leads of direct current, because in the former case the direction of the voltage is constantly changing.

If, for example, it is desired to synchronize one 220-volt three-phase alternator with another that is in operation, the speed and voltage of the incoming machine should first be adjusted to approximately the same value as that of the operating machine. Let No. 1, Fig. 1, be the equipment that is in operation and No. 2, the incoming machine which is to be synchronized with No. 1, so that when switch "S" is closed the two sources will operate in parallel. The leads marked A, B, and C from the second alternator are connected to the bottom of the knife switch "S" and the lamps L-1 and L-2 are connected as shown in the diagram. The center poles of the three-pole switch are connected together by a wire. Some engineers connect the center poles with a lamp also, in which case but one 220 volt lamp would be needed between any two poles, as the voltage across any lamp could never be greater than 220 volts. The voltage of the lamps used should be twice the voltage of the apparatus being synchronized because in out of phase positions the voltage across the lamps would be 440 volts, as the two sources would be temporarily in series.

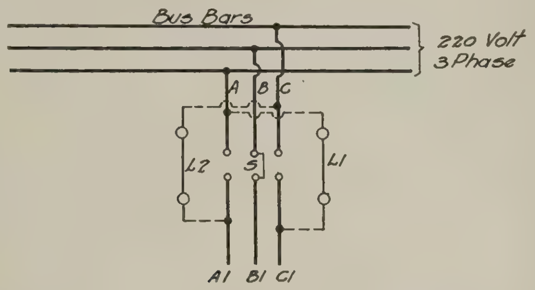


Fig. 2. Connections for Synchronizing 220-Volt Three-Phase Generators; Switch Is Closed When Lamps Are Brightest.

When these switch connections have been made No. 2 alternator is started up and brought up to the correct voltage and speed, it being understood that No. 1 is already in operation. If the two sets of lamps light up and darken simultaneously it shows that the corresponding phases are connected together correctly through the switch "S," but if L-1 is bright when L-2 is dark, it shows that one phase is reversed and two of the leads must be reversed. When the phases of the two sources are properly connected and the machines are both running approximately at the same speed, as shown by the brightening and darkening of the lamps, the switch "S" should be closed when the lamps are all dark. This will lock the two machines or sources of alternating current in synchronism and the proportion of power that each will deliver thereafter will depend upon the power of the driving machinery rather than upon the voltage of the two sources, as in direct current parallel operation. The diagram in Fig. 2 shows the connections that are necessary to synchronize two alternators when the lamps are bright instead of dark.

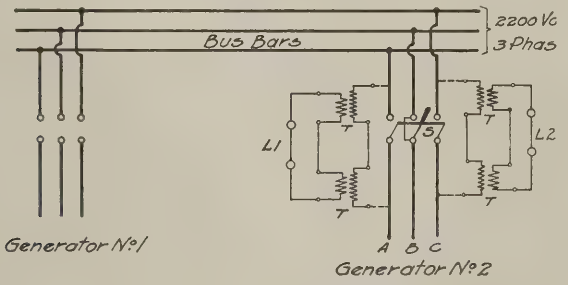


Fig. 3. Connections for High Voltage Synchronizing on 2200 Volt Three-Phase Circuit. Primary Windings of Transformers "T" Take the Place of Lamps in Figs. 1 and 2. Lamps Are Connected in Series With the Secondaries of the Transformers.

Synchronziing High Voltage Sources

Modern alternating current machinery generally operates at too high a voltage to make this method of synchronizing applicable, as it would be necessary for so great a number of lamps to be in series that the method would be cumbersome. So for the second case let us suppose that we have conditions identical with case one with the exception that the voltage of the two sources is 2,200 volts instead of 220 volts. The poles "B" on the switch "S," shown in Fig. 3, are again connected by means of a wire and instead of lights it is more practical to use transformers, as shown in the figure. Four transformers with a primary winding of 2,200 volts and a secondary for 220 volts could be used, two 220-volt lamps being connected in series with the secondary windings, as shown. The method of synchronizing would then be identical with case I.

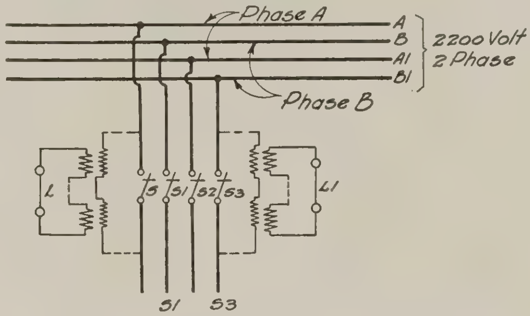


Fig. 4. Connections for Synchronizing 2200-Volt Two-Phase Generators.

It is doubtful whether so many transformers would be found available, at one time in a small station, in which case it might be necessary to drop the voltage of the two equipments quite considerably, but keeping the correct speed and then using only two transformers instead of four, one being used to replace the two in series, as shown on the diagram. If it were desired to synchronize with the lamps bright the primaries of the transformers would be connected as the lamps were in Fig. 2.

Two-Phase Synchronizing

The connections that would be necessary to synchronize a two-phase 220-volt source of energy with two-phase bus bars operating at the same voltage are shown in Fig. 4. The leads S, S1, S2, S3 are the leads from the incoming two-phase alternator. The four transformers would be connected as shown, each transformer being for 2,200-volt, 220-volt operation. The left hand transformers are connected in phase "A" and those on the right in phase "B." It is first necessary, of course, to determine which two leads come from one phase and which

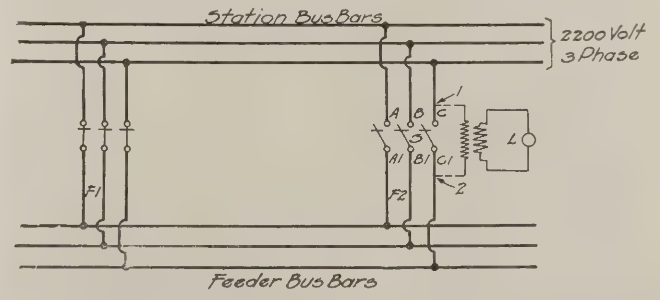


Fig. 5. Connections for Testing Out Phases of Two Transmission Line Feeders Which Are Already Locked in Snychronism at Some Other Point.

from the other. The switch S2 should be closed and the machine started and run up to its proper voltage and speed and when the lamps "L" are dark, switch S1 should be closed, lock phase "A" in synchronism with the corresponding phase of the other machines. Switch S1 should then be closed and if the lights are bright it would show that leads S1 and S3 should be reversed as the two phases winding are in series. If the lamps are dark the switch S3 can then be closed and both phases will be operating in parallel.

Phasing Sub-Station Feeders

It often happens that when two stations are situated but a short distance apart and are already tied together by one set of feeders F1 (see Fig. 5), it is desired to increase the capacity by connecting through another set of feeders F2. But one transformer is required to test out the phase relations. Leads from the two buses are connected to the switch "S," one primary transformer lead being connected to a pole on the top of the switch S and the other is then connected to each of the leads at the bottom of the switch until when so connected the lights remain out. These two leads should then be connected on opposite points of the switch. In this way the phase leads are properly identified and the switch can be closed.

Synchronism Indicators

The methods described above for synchronizing alternating current machinery are still used in small stations, having small units, but in modern power plants a more exact method of synchronizing had to be developed to meet the new conditions. This led to the invention of the synchronizing instrument. This obviates the large flow of cross current which would result from throwing two large units in parallel which were slightly out of phase with each other, as might result from synchronizing with lamps.

There are several different types of such indicators on the market and, if properly installed and connected, will render good service, but the type that is used most extensively and considered superior by engineers is the Lincoln synchronizing instrument, which will be described below.

A perfect device for synchronizing two or more alternating current machines should perform the three following functions: (1) It should indicate whether the incoming machine is rotating slower or faster than the operating machine; (2) it should indicate the difference in the machine speeds, and (3) it should accurately indicate the instant of coincidence in phase of the incoming and operating machines.

Lamps do not perform the first functions, while they do the second well, and the third approximately. Voltmeters used in place of lamps performs the third function, but voltmeters are not always at hand and do not meet the first requirement. The Lincoln instrument performs all three. The pointer moves about the dial like a hand of a clock, but being able to move in either direction. The angle of the pointer displacement from the vertical position measures the angular phase difference of the two sources of electro-motive-force. If the incoming machine is running too fast, the pointer rotates in one direction, if too slow, in the opposite direction, while coincidence in phase is shown when the pointer remains in a vertical position, at which point the inter-connecting switch should be closed, throwing them in parallel. A complete revolution of the pointer shows the gain or loss of a complete cycle of the incoming machine over the operating machine.

The Lincoln Indicator

Every electrician who has alternating current work to do will probably sooner or later be called upon to install or repair one of these instruments, and he should be familiar with its internal and external connections, as shown diagrammatically in Fig. 6.

The principle of operation of this instrument is similar to that of a small motor the field of which is energized or excited by the operating machine. The armature of this instrument is of the drum type, having two coils with their axes at right angles to each other and connected in series as shown. A conductor is tapped on the junction of the two coils, this and the other ends of the windings are brought out through slip rings. One brush lead is then run through the inductance coil N1 and the other through the non-inductive resistance I. The current in the coil connected in series with the inductance will then lag behind the current in the other coil about 90 degrees. This will set up two magnetic poles on the armature mechanically at right angles and the current flowing in them 90 degrees out of phase electrically, so that when the armature is in any position one coil or the other, or combination of both, reacts on the fixed poles to hold the armature in a definite position indicating the phase relation of the two machines.

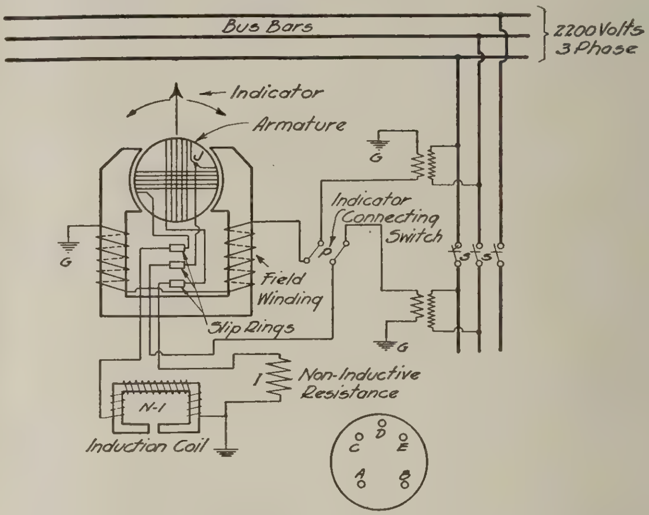


Fig. 6. Wiring Diagram of the Lincoln Synchronism Indicator.

This diagram shows a grounded system but if a metallic system is desired, the points marked G should be connected together by wires, or another plug switch "P," but the grounded system has given very good success and is simpler.

The pointer of the instrument is fastened to a small shaft from the armature and on the synchronism position it is flat so that set screw can hold the pointer in this position. In cases where this hand has been moved off this position to make the hand show synchronism it is because of some fault in the connections, and the trouble usually is that the ground points are not getting good connections or that there is a bad unbalanced resistance in the wires that are used to connect the instrument both of which would tend to throw the hand to one side or the other of zero at synchronism. The small circle at the bottom of the figure shows the back connections, the fields always being connected to the points marked (A) and (B), while the common junction in the armature winding is connected to point (E) and the others to binding posts (C) and (D).

These instruments can be tested for correct synchronism position by using a common single phase current for both the fields and armature, at which time the pointer should stand in a vertical position. It should also be remembered that when connecting them for use on two phase work that the same phase of both the running equipment and that to be synchronized should be used, otherwise the pointer will indicate synchronism when the machines are 180 degrees out of phase.

The Principles of Alternating Currents

Willard Doud

The rapidly increasing use of alternating current in railroad service has forced the railway electrical engineer to become familiar with the various forms of apparatus available for its generation, distribution, and utilization. While practically every individual concerned with the handling of electricity is familiar with the basic principles and characteristics of direct current, the rapid development and production in finished form of alternating current apparatus has not given the same opportunity for becoming familiar with the underlying principles of alternating currents as was possible with the step by step development of direct current apparatus.

Formulae for accurately determining the various characteristics of alternating current in its various forms are available and in common use, but unfortunately, on account of the mathematics involved, do not present to everyone interested a clear understanding regarding the exact meaning of the various qualities of alternating currents and their similarity or dissimilarity to the action of direct currents. In outlining the principles of alternating currents use will be made of the hydraulic analogy in various forms. This method, while elementary and not entirely accurate, possesses the advantage of presenting to the mind's eye, the questions involved in a clearer manner than would be possible either by a volume of words or a multitude of wiring diagrams.

Systems of Distribution.

In general, it may be stated that there are two systems of electrical distribution: (a) Direct Current (D.C.) in which the flow is always in one direction; (b) Alternating Current (A.C.) in which the flow is first in one direction and then in the other, or alternating, from which quality it derives its name.

The D.C. system may be divided into two classes (a) Constant Current, in which the current remains constant regardless of the resistance of the circuit; (b) Constant Voltage, in which the pressure or voltage remains constant, regardless of the amount of current flowing.

A constant current generator may be compared to a plunger pump which is delivering a constant volume of water regardless of the resistance of the piping or the pressure against which it is working; while a constant voltage generator might be likened to a centrifugal fan, which delivers a constant pressure for any flow of air up to the capacity limit for which the fan was designed.

The use of constant current direct current has been confined practically to series arc lighting in the western hemisphere, while in Europe it has been used to some extent in the transmission of power over long distances, extremely high pressures being used.

Constant voltage direct current is in common use and is being handled to some extent by every electrical engineer.

The A.C. system likewise may be divided into two classes (a) Constant Current, possessing somewhat similar characteristics to the D.C. constant current class and is used almost entirely in series lighting service; (b) Constant Voltage, also comparable in a measure to the direct current constant voltage class, is further divisible into (1) Single Phase and (2) Polyphase, meaning more than one phase.

Single phase current originally was used for lighting purposes only, but has been developed for use in railway traction service and for the operation of industrial motors, principally in the smaller sizes. The use of polyphase current practically is limited to the two phase and three phase systems of distribution and from present indications it is but a question of time until two phase distribution will be entirely displaced by three phase for ordinary service.

General Principles.

As is well known, the generation of e.m.f. or pressure in an electrical conductor is based on the well established fact that whenever lines of magnetic force are cut by a conductor an e.m.f. or pressure is produced in the conductor and that the value of the e.m.f. depends on the time rate of the conductor in its operation of cutting the lines of magnetic flow. It is also well known that a current will flow only when there is a closed electrical circuit.

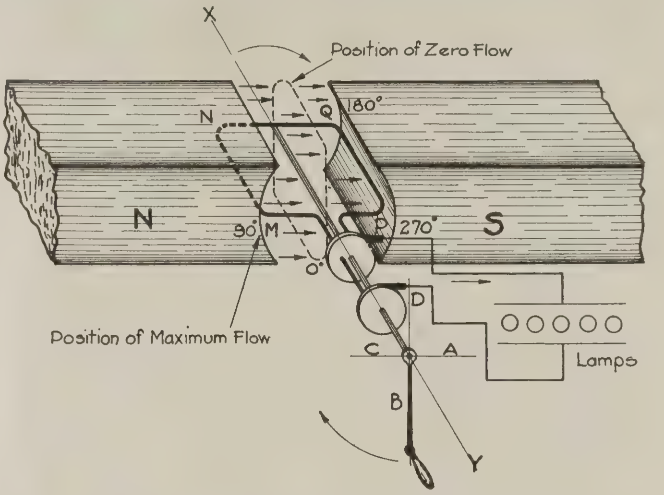


Fig. 1. Elementary A. C. Generator Consisting of Two Poles and One Armature Coil.

Following the above principles, it may be said that the operation of all commercial electric generators and motors is based on the fact that when a coil of wire is moved in a magnetic field so that the number of magnetic lines threading through the coil is changed, a pressure or voltage is produced in the coil and if the ends of the coil are connected together, a current flows through the coil.

Conversely, if a current is passed through a coil placed in a magnetic field, the coil will tend to revolve so as to increase the number of magnetic lines through the coil. Whenever a coil is rotated in a magnetic field, the magnetic lines pass through the coil first in one direction and then in the other, causing the pressure or voltage at the terminals of the coil to reverse or alternate, and if the ends of the coil are joined, current to flow in the coil back and forth in the wire.

The Elementary A.C. Generator.

Fig. 1 shows a diagram of the simplest form of generator which is in effect a loop of wire arranged to rotate in a uniform magnetic field. The generation of pressure or voltage by this generator will be according to the following procedure: With the loop in the position shown in the diagram, or with its plane parallel to the line of magnetic flow, and rotating in the direction indicated by the arrow, or clockwise about its axis X-Y, the sides M-N and P-Q, which cut lines of magnetic flow, will have a pressure or voltage induced in them which will cause a current to flow in a direction indicated by the arrows. The value of this voltage will depend upon the speed or the rate of cutting the lines of magnetic force and will be greatest with the loop in position indicated in Fig. 1 with crank position B. As the loop approaches the position shown by dotted lines the voltage gradually decreases because the time rate of cutting is decreasing until the 180° or crank position, C, is reached, when no lines are cut and the voltage is zero. Continuing the rotation until crank position, D, or 270° is reached, the voltage again becomes a maximum, but with the difference from crank position B, that the cutting of the magnetic lines of force is now from the opposite direction and consequently the polarity of the pressure or voltage generated has been reversed. Progressing in its rotating path the voltage in the coil decreases until the 0° or A crank position is reached, when it is again of zero value. Leaving the A crank position, the direction of the pressure or voltage is reversed and gradually increases until the 90° or B crank position is reached, when it again is at its maximum.

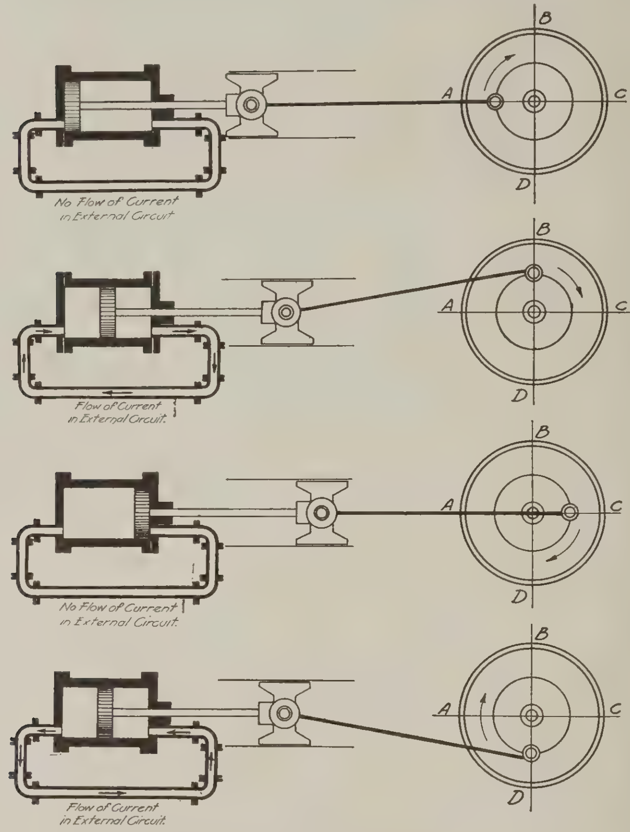

B
A
C
D
No Flow of Current in External Circuit
B
A
C
D
Flow of Current in External Circuit
B
A
C
D
No Flow of Current in External Circuit
B
A
C
D
Flow of Current in External Circuit

Fig. 2. Hydraulic Pump Representation of an Alternating Current Generator.

In passing through the four crank positions there has been produced in the coil two complete changes from zero to maximum voltage, increasing and decreasing in value at a uniform rate and differing in direction only. The completion of this revolution produces a combination of two reversals of pressure, or what is called a *cycle.*

Sixty cycle current is perhaps the most commonly used in commercial service and is the result of producing in the generator 60 double reversals of pressure or voltage per second, and is the equivalent of 7200 alternations or changes in direction per minute.

Hydraulic Analogy of A.C. Generator.

In Fig. 2 is shown an arrangement consisting of a piston and cylinder with a pipe connection between both ends of the cylinder and a crank and connecting rod attachment for operating the piston. Considering the cylinder and piping as filled with water; if the crank is revolved, the piston will be moved back and forth and the water will be forced through the pipe first in one direction, then in the other, or, in other words, an alternating current is produced in the pipe.

In this analogy the piston moving back and forth may be likened to the coil rotating in the magnetic field and the flow of water in the cylinder and pipe to the flow of current and voltage in the coil and external circuit with is varying rates of flow and direction.

If the crank is rotated at constant speed in the direction indicated by the arrow, starting at A, the speed of the piston is zero, as it moves to the right its maximum speed is reached at B from which point it gradually decreases in speed until C in reached. when it again is at rest. Moving to the left, the speed is again at a maximum at D and diminishes until point A is reached, when it is at a point of rest or reversal.

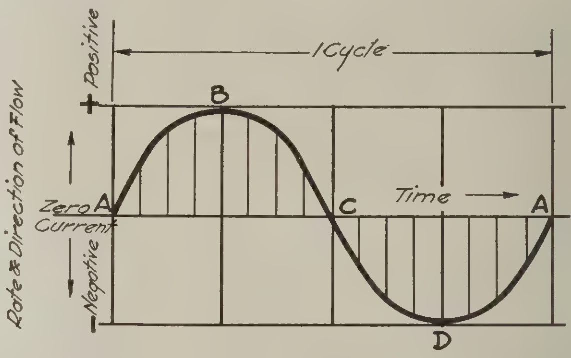


Fig. 3. Instantaneous Values of Current or Voltage of an Alternating Current Generator Over a Period of One Cycle.

In passing over the above path the piston has covered two strokes or alternations and has completed what is equivalent to a cycle. From this analogy it will be seen that the rate of flow in the piping corresponds to the speed of the piston just as the rate of flow in the simple generator shown in Fig. 1 followed the time rate of cutting the magnetic lines of force.

Fig. 3 shows a geometrical representation of the rate and direction of flow of alternating current during one complete cycle. The line A-C-A represents the time required for one cycle and the vertical lines between A-C-A and the curved line represent the instantaneous values of voltage with the various positions of the generating coil during one complete revolution or cycle. By joining the ends of the instantaneous voltage values the curve A-B-C-D-A is obtained. A study of this curve shows that at the beginning of the cycle, the voltage increases to a maximum in a positive direction, diminishes in value to zero, increases to a maximum in a negative direction and gradually decreases in value until zero is again reached, thus completing one cycle. At the points B and D the generating coil in Fig. 1 is cutting the magnetic lines of force at the highest time rate, consequently the voltage is at a maximum at these points and for intermediate positions the voltage varies with the rate of cutting of the lines of force by the generating coil.

At the points B and D of Fig. 2 the pump piston is traveling at its greatest velocity and, consequently the flow of water in the pipe is greatest at these points. As the piston either approaches or recedes from these positions the flow of water either increases or decreases, following in effect the vertical lines which go to make up the curve A-B-C-D-E.

It has been shown in the above that the rate and direction of the flow of alternating current varies with the speed and direction of the generating coil in cutting the magnetic lines of force, and it is interesting to note in what manner direct current differs from alternating current.

The Elementary D.C. Generator.

Assuming that direct current is desired, if the statement is true that the operation of all commercial electrical generators is based on the fact that when a coil of wire is moved in a magnetic field, so that the number of magnetic lines threading through the coil are changed a pressure or voltage is produced in the coil and if the ends of the coil are connected together, a current flows through the coil, the generator shown in Fig. 1 may be used with some arrangement provided for changing or commutating the direction of the current. Such a device is called a commutator and Fig. 4 shows a simple generator similar to that shown in Fig. 1 but with the addition of a two-segment commutator. The effect in the generating coil is the same as that in the generator of Fig. 1 between crank positions A and B and B and C. When the coil reaches the neutral point midway between the poles as shown in Fig. 4-b there will be no voltage generated and no current flow. As it moves further around as shown in Fig. 4-c it will develop a reversed voltage in the coil. Since the commutator has now reversed its contact on the brushes, however, the polarity of current flowing through the lamps or other external circuit will be the same.

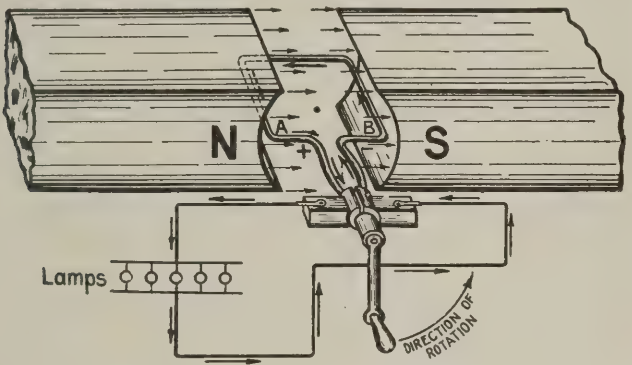


Fig. 4a. Elementary D. C. Generator With One Armature Coil. In This Position it Is Cutting Maximum Number of Magnetic Lines So Voltage and Current Flow Will Be Maximum.

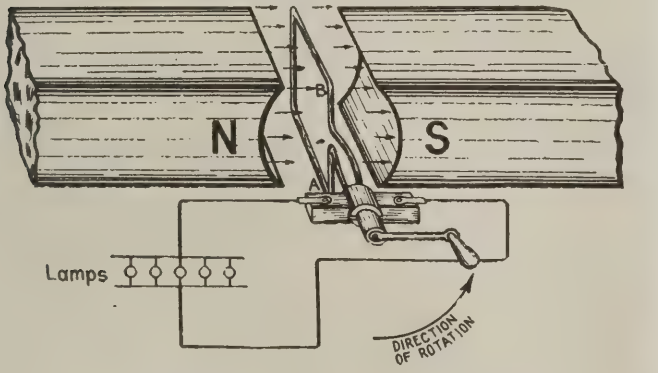


Fig. 4b. Coil in the Neutral Plane; No Magnetic Lines Being Cut and No Voltage Generated So No Current Will Flow.

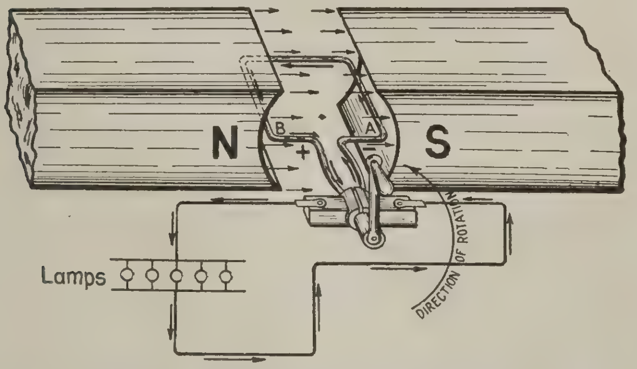


Fig. 4c. Coil Again Cutting Maximum Magnetic Lines But in the Other Direction. Commutator Reverses Connections to External Circuit So Voltage Across Brushes Will be the Same as in 4a.

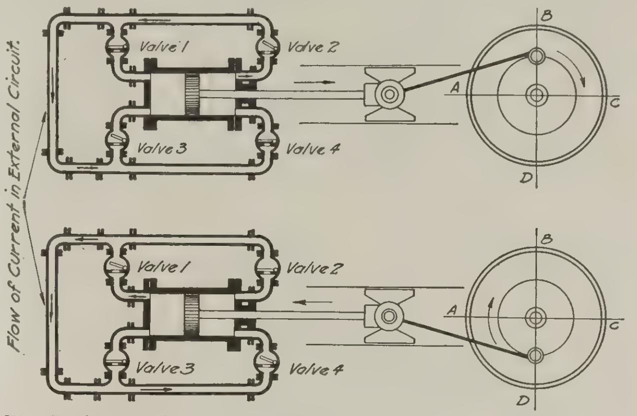


Fig. 5. Hydraulic Pump Representation of Direct Current Generator, the Valves Corresponding to the Commutator.

From the above it will be seen that direct current is the same as alternating current during the first half of the producing cycle and differs only in that the flow during the second half of the cycle has been changed in direction to correspond with the flow produced during the first half.

Hydraulic Pump Analogy of D.C. Generator.

Figure 5 shows a piston operating inside of a cylinder with a crank and connecting rod attachment similar to that included in Fig. 2. It will be noticed, however, that the piping arrangement is different and somewhat more complicated by the addition of four valves and suitable piping connections. As in Fig. 2, with piping and cylinder filled with water, if the crank is revolved, the piston will be moved back and forth in the cylinder, but through the action of the valves the flow of water in the main will be in one direction only; that indicated by the arrow. Starting at crank position A, the speed of the piston is zero and as it moves to the right, the pressure in front of the piston opens valve 2 and closes valve 4 and the suction behind the piston opens valve 3 and closes valve 1 and forces the flow of water in the main in the direction of the arrow. The maximum speed of the piston is reached at crank position B, or after it has passed over 90°, and from this point decreases until the C, or 180° position of the crank is reached, when it is again at rest and ready for reversal. In moving to the left, the piston causes valves 1 and 4 to open and valves 3 and 2 to close by

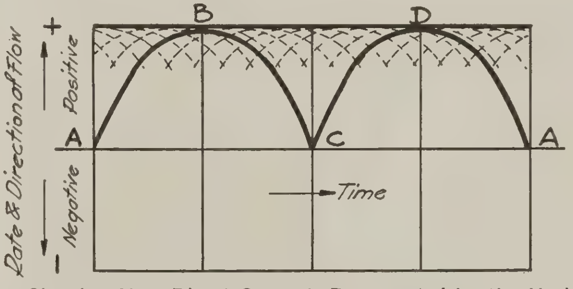


Fig. 6. Showing How Direct Current, Represented by the Horizontal Line B. D. Is Merely a Combination of a Great Many Rectified Alternating Current Waves.

action similar to that indicated for the first half of the revolution. This action also causes the water in the main to flow in the same direction. At crank position D, or after it has traveled 270°, the piston is again at a maximum speed in a reverse direction, from which point its speed gradually decreases until it has dropped to zero at crank position A, when it has completed two points, its speed gradually decreases until it has completed two strokes or traveled through 360°.

From this analogy it will be seen that the rate of flow of water in the piping follows the speed of the piston in the cylinder at all times but does not correspond in direction during the return portion of the revolution and is in effect the same action which occurs during one complete revolution of the generating coil in the simple generator fitted with commutator outlined in Fig. 4.

A geometrical representation of the action described above is shown in Fig. 6. The line A-C-A represents the time required for one revolution of the generating coil, and the vertical distances between the curved lines A-B-C and C-D-A the instantaneous values of flow for any time during the revolution.

A study of the heavy line curves shows that at the beginning of the stroke or revolution the flow is zero, increases in value to a maximum in a positive direction, diminishes in value to zero, increases in value again to a maximum in a positive direction and again decreases to zero. Also that the flow is a series of impulses of the same intensity and direction.

In following the curve and the diagrams presented to illustrate the action of direct current it must be understood that the generating coil in Fig. 4 and the piston, cylinder and crank in Fig. 4 show the action of one coil only and to make the current effective for use and practically continuous in effect as regards pressure or voltage the number of coils and commutator bars must be multiplied in order to bring the apparatus within the limits of speed application and commutation of current.

It is apparent that with an apparatus similar to the arrangement shown in Fig. 5, if trouble was experienced at high speeds and pressures, it might be expected in the valves or commutating device. This analogy holds with reference to D. C. apparatus where the chief source of trouble is with the commutator and although modern direct current machines leave little to be desired as far as commutation is concerned, the commutator and complimentary parts are the portion of the machine usually requiring the most attention. To obtain the desired effect in the production of direct current, a large number of generating coils with a proper commutating arrangement are mounted on a device arranged for revolving in a properly arranged magnetic field and called an armature. The effect of multiplying the number of coils is shown by dotted curved lines in Fig. 6, and results in a constant rate of flow being maintained without objectionable fluctuations of a practical nature.

(*This course on alternating current machinery will be continued next month.*)

A. B. C. Car Lighting Course

Edited by Edward Wray

Lesson No. 37

Safety Type "F" Axle Lighting Equipment

In the preceding lesson we described in detail the construction of the Safety Type "F" axle car lighting equipment and we hope to give in this lesson information on the operation, installation of repair parts, and dismantling, which will give the men on the job a good idea both as to how the equipment operates and how it should be taken care of. These two lessons go together and the reader should study over the previous lesson before proceeding with this one. Next month we will take up the subjects, of inspection, tests and cleaning ball bearings. In last month's lesson we stated that it was prepared with the co-operation of the engineering department of the Safety Car Heating & Lighting Co.; this, however, was not the case and that statement was in error.

Operation.

When the car is at rest the automatic switch is open and the generator is disconnected from both battery and lights. There is no voltage generated across the armature terminals and no current flowing through the field coils. There is a certain amount of magnetism in the iron of the generator fields however, this being known as "Residual magnetism."

When the car begins to move and is traveling at low speed, this residual magnetism causes a low voltage to be generated in the armature, which forces a small amount of current through the three parallel circuits,—lifting coil "J" of the automatic switch, the generator field coils and the voltage regulating coil "A". These circuits are entirely disconnected from the part of the system, which includes the battery, lamps and lamp regulator.

In the diagram, Fig. 191, the wires of these three circuits which carry current at low speed are shown solid. The other wires of the circuit through which no generator current can pass under the above conditions are shown dotted.

As the low voltage generated by the armature revolving in the residual magnetism of the generator fields, forces current through the field coils this current at once begins to strongly build up the generator field magnetism and greatly increases the voltage generated in the armature; when the train is below cutting in speed or "critical speed," however, this will not be sufficient to close the automatic switch. As the train speed rises the voltage of the generator will rise correspondingly and this in turn will force more current through the field windings of the generator, causing a still further rise in voltage. In other words, the generator voltage rises due both to the increase in field strength and also to the increase in speed of rotation. When the train speed reaches such a value that 34 volts are generated in the armature this forces current through the lifting coil "J," generating sufficient magnetism in that coil to lift the plunger of the automatic switch, closing it and connecting the generator directly to the battery and lamp circuits. All the dead wires shown dotted in Fig. 191 then become live.

Automatic Switch.

The amount of current flowing through the lifting coil "J" will depend upon the voltage generated in the armature. On low speeds this will generate only a weak magnetic field within the lifting coil, but as the voltage of the generator, due to the increased train speed and to its own increased field strength, rises to about 34 volts, the current through the lifting coil "J" will then generate sufficient magnetism to lift the pivoted iron armature (A, Fig. 192) of the automatic switch and connect the generator directly to the storage battery and lights.

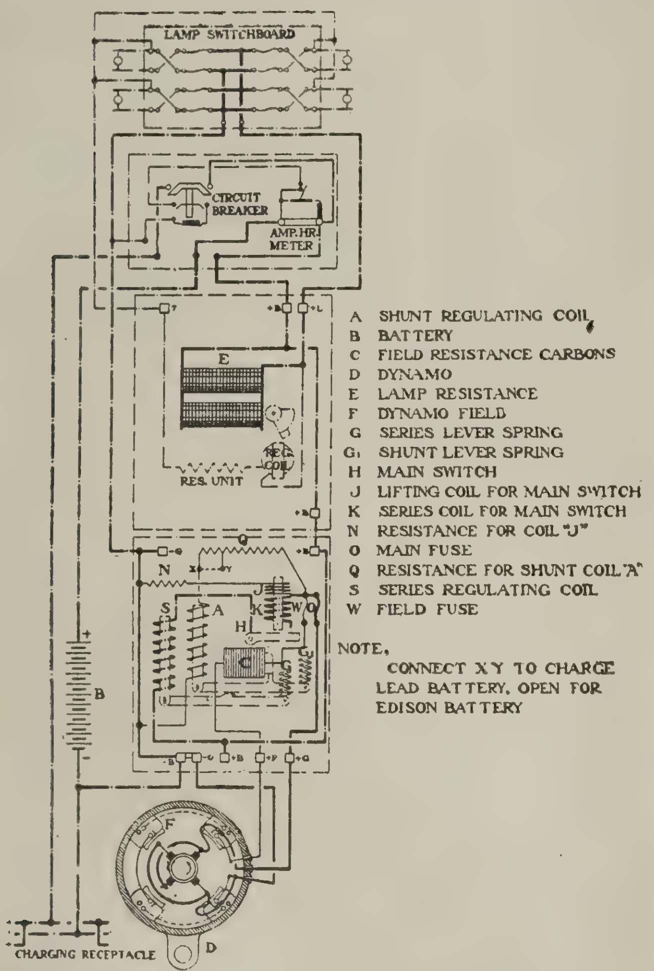


Fig. 191. Wiring Diagram of Safety Type "F" Equipment. Solid Lines Show Live Circuits When Generator Is Below Cutting in Speed; Dotted Circuits Are Then All Disconnected From the Generator.

Since the battery has previously been standing either on an open circuit or dicharging into the lamp circuit, its voltage will usually be below the value of the 34 volts delivered by the generator when the switch closes, and current will flow from the generator into the battery and lamps. This current flowing from the generator to battery and lights flows through the series coil "K" of the auomatic switch and generates magnetism within that coil, which adds to that of the lifting coil "J" and greatly increases the pull on the pivoted armature and holds the switch firmly closed.

While the train is operating above cutting in speed the generator output will be held to normal value by the regulator regardless of how the train speed may vary, as explained later. If the train speed falls to cutting in speed the voltage of the generator will again be reduced to 34 volts. If the storage battery happens to be in such a condition at that time that its voltage is also 34, there will be no current flowing from the generator to the battery and the lamps will probably be momentarily fed from both generator and battery. When the generator voltage falls a fraction of a volt lower, all lamp current is supplied by the battery and no current flows from the generator through the series coil of the auto switch. Meanwhile, however, although the voltage of the generator may be slightly below the cutting in voltage, the switch remains closed, for once the iron armature of the switch is pulled up, this closes the air gap between the iron yoke and the core and so strengthens the magnetic flux that a much lower voltage will hold the switch closed than is required to pick up the armature. A further decrease to train speed will cause the voltage of the generator to fall below that of the battery. This will permit the storage battery to force current back through the generator, tending to run it as a motor. This reverse current flowing through the series solenoid "K" generates magnetism which opposes the magnetism of the shunt lifting coil "J" and weakens its pull on the pivoted armature to such a point that the switch drops open. At this time there is, of course, a reverse current of a few amperes flowing through the switch contacts and a slight arcing takes place when the switch opens. Carbon block break points are provided, however, so that the slight amount of arcing does no damage. Care should be taken to see that this carbon break of the automatic switch is kept in good condition, for if it gets out of order the copper laminated brush may become seriously burned by arcing at the opening of the switch.

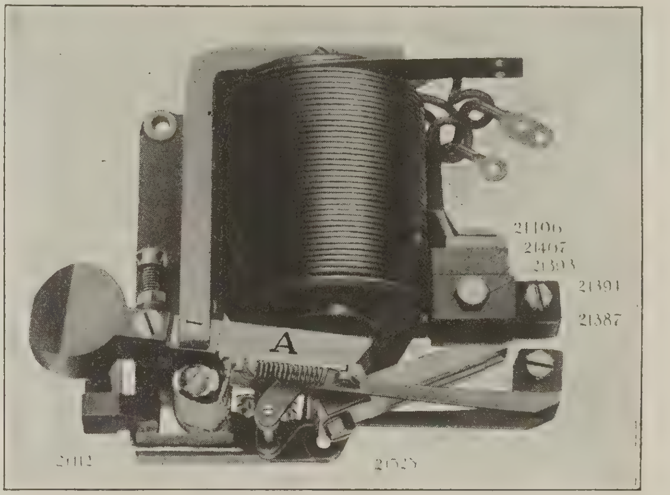


Fig. 192. View of Automatic Switch.

Generator Current Regulator.

As soon as the automatic switch closes the generator is connected in parallel with the battery and lamps and current will flow from the generator to the lamps and also to the battery if its voltage is below that of the generator. The actual amount of current delivered by the generator as soon as the automatic switch closes depends on the number of lamps turned on at that time, but more particularly it depends upon the voltage of the battery. If the battery is in a full state of charge and its voltage is high, it may not take any charging current the instant the automatic switch closes; in fact, it may sometimes assist the generator in carrying the lamp load. If the battery is in a low condition of charge, however, so that its voltage is well below that of the generator, current will flow into the battery the instant the switch closes.

As the train speed increases the generator output will increase until it has reached its full current output. This current goes part to the battery and part to the lights, or all to the battery if no lamps are turned on. The regulator controls the generator so that its full output cannot be exceeded.

This regulator controls both the generator current and voltage to proper value. It limits the current output to the generator capacity and the voltage to 39 volts. It is essentially a constant current regulator so long as the battery and lamps require the full generator output but it becomes a constant potential regulator when the current required is less than this full output.

Assuming that no lights are on and the battery is in a low condition of charge so that it requires only 35 volts to force a battery charging current of 62 amperes to flow, as shown in Fig. 196; the force exerted by the levers in releasing the pressure on the carbon piles will be caused by the magnetic pull of both the series regulating coil "S" and the voltage regulating coil "A" on their iron plungers, in other words, both coils work together. The rear lever, which is operated by the plunger of the voltage coil "A," controls directly the pressure on the carbon pile "C." A finger projecting back from the front lever bears against a a similar finger on the rear lever and allows the front lever to raise the rear lever and so decrease the pressure on the carbon pile when the current through the series solenoid tends to rise above normal value.

It takes a certain total pull to raise both plungers and overcome the pull of the adjustable springs G and G-1. The magnetic pull of the voltage coil "A" on its plunger is not strong enough to raise the plunger at this voltage, but as the two levers work together through the projecting fingers mentioned above, the series coil will assist the voltage coil in lifting its plunger. In other words, for a certain position of the iron plungers in their coils, it requires a certain number of ampere turns total in both coils, to lift both plungers and overcome the pull of both the adjustable springs G and G-1.

The voltage coil will balance the pull of its spring when the voltage is 39, and the series coil will balance the pull of its spring when the current is 60 amperes. If the voltage is less than 39 the current in the series coil will be slightly more than 60 amperes in order to make up for the decreased pull of the voltage coil at the lower voltage. This is shown in Fig. 196, where the current decreases slightly as the voltage rises from 35 volts to 39 volts.

The length of the two iron plungers is so adjusted that as the plungers are drawn into the coils on higher speeds, the magnetic pull will be automatically increased to provide for the increased pull required to stretch the springs a little and produce a balance.

In the above discussion we have been concerned chiefly with explaining how the battery charging current tapers off as the charge proceeds. We will now consider how the regulator acts in controlling the output with varying train speeds.

The total generator current flows through the series coil "S", Fig. 193, and when the generator delivers 60 amperes, this current will develop sufficient magnetism in the coil "S" to lift its plunger against the pull of the spring "G." Assuming the battery to be in a discharged condition the generator voltage will now be about 35 to 38 volts. A further increase of train speed will tend to raise this voltage and this will increase the battery charging current. This increase in current through the coil "S" will increase the magnetism of that coil, causing it to pull upward on its plunger more strongly and, acting through its lever finger, will raise the rear lever and slightly release the pressure on the carbon pile "C," Fig. 193. This will increase its resistance and since as this carbon pile is in series with the generator field, will slightly decrease the generator field current, causing the generator voltage to fall until the output is reduced to 60 amperes. As the train speed goes still higher the plunger will be lifted further into the coil "S" further decreasing the pressure on the carbon pile "C" will further reduce the generator field current to compensate for the rise in train speed and control the generator output to the normal value of 60 amperes. The output is thus maintained constant at this value regardless of what the speed of the train is.

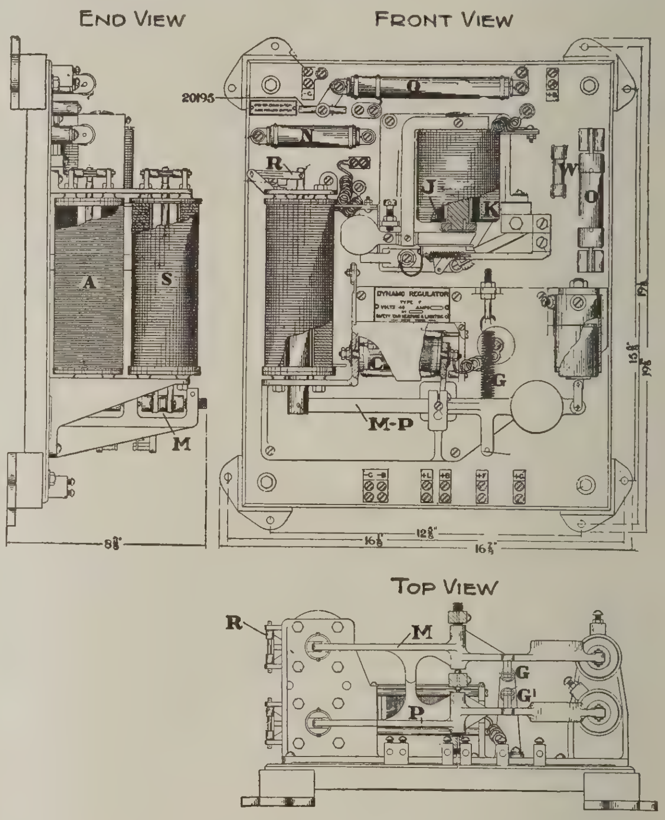


Fig. 193. Views of Safety Type "F" Generator Regulator.

As the train speed decreases, the plunger of the coil "S" will gradually lower, and this movement acting through the lever arms will gradually increase the pressure on the carbon pile "C," reducing its resistance and allowing the generator field current to increase so as to compensate for the decrease in train speed and keep the generator output constant at 60 amperes.

Action of Voltage Regulating Coil.

As the battery charge proceeds at 60 amperes or something less, its voltage will gradually rise and the generator voltage will also rise, always keeping ahead of the battery voltage in order to force charging current to flow. The voltage coil "A" receives full generator voltage but until the battery charging voltage rises to 39 volts the magnetism generated in this coil will not be sufficient to lift its plunger. It is, however, nearly able to do so and requires only a slight assistance from the lever of the series solenoid to raise the rear lever and adjust the pressure on the carbon pile to proper value. When the charging voltage rises to 39 volts, however, the voltage coil "A" will be able to lift its plunger alone and the projecting finger on the front lever will gradually drop away from the projecting finger on the rear lever. The voltage regulating coil, prevents the generator voltage from rising above the setting of 39 volts, so from this point on the regulator will operate on a constant potential basis and the generator output will gradually taper off as the counter electro motive force of the battery rises and opposes the flow of charging current.

The voltage limit of 39 volts as mentioned above applies only where lead batteries are used. The Edison storage battery requires a maximum voltage of 42.5 volts (measured at the battery terminals) for full charge and in order to permit the generator to develop the required 42.5 volts, an additional resistance shown between the points X and Y of the resistance "Q" is inserted in series with the voltage coil "A," Fig. 193. In other words, this additional resistance requires a higher generator voltage to force the required amount of current through the windings of the coils "A" in order to enable it to lift its plunger and overcome the pull of the spring G-1. In order to adjust the regulator to operate with the Edison battery, insert this additional resistance X-Y, Fig. 193, by disconnecting (sliding to the left) the small brass rod at the upper left hand corner of the panel, Fig. 193. The brass rod should bridge across a section of the resistance "Q" when a lead battery is used and should be disconnected when an Edison battery is used.

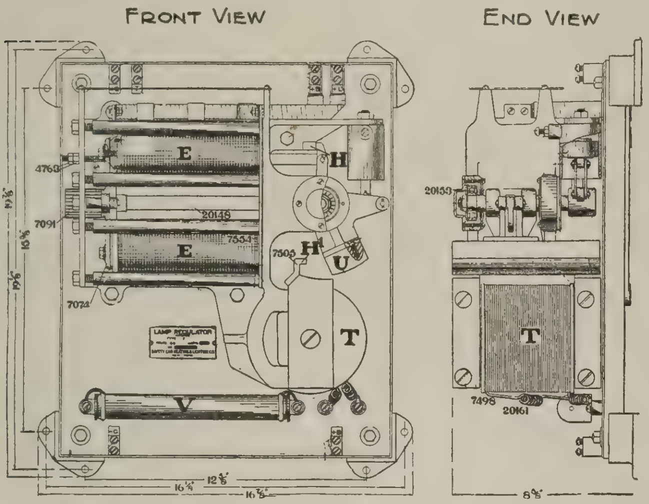


Fig. 194. Views of Safety Type "F" Lamp Regulator; "T" Operating Solenoid; "U" Magnet Armature; "E" Carbons.

In general terms, then, the regulator we here describe works as a constant current regulator at first, delivering about 60 amperes when the battery is in a low state of charge, and operates as a constant voltage regulator maintaining the generator voltage at 39 volts with lead battery and 42.5 volts with the Edison battery after the battery voltage has risen to this value.

Prevention of Overcharge.

Since the battery charging current tapers off to a low value at the end of charge overcharging is reduced, and accordingly there is no voltage cut out switch provided. It should be pointed out, however, that unless the voltage coil is carefully adjusted to 39 volts the final charge to which the current tapers will vary materially. If the voltage coil is set two or three volts higher than normal the current instead of tapering to 5 or 10 amperes at the end of charge as it should, may be from 35 to 50 amperes. In this way the good offices of the constant voltage feature of the system in preventing excessive overcharge will be partly lost and overcharging to a certain degree may result.

On a few of these equipments on one railroad the ampere hour meter has been very ingeniously used for controlling the charge given a battery on an ampere hour basis. The zero contact of the meter, which closes at full charge, simply short circuits part of the resistance "Q," Fig. 193. When this takes place the regulating coil "A" reduces the generator voltage to 36 volts instead of 39 volts as normally and the battery is floated on the line without any charge whatever. The manufacturers state, however, that this has not been tried to an extent to warrant making many claims for it.

Lamp Regulator.

In order to prevent flickering of the lights and also to prevent excessive voltage which would blacken the lamps and shorten their life, a lamp regulator is provided to maintain constant voltage on the lamp circuits. Since the generator voltage must vary from 34 to 39 volts in charging the storage battery the lamp regulator must absorb this variation in voltage and maintain a constant voltage of 32 volts on the lamps. A variable resistance consisting of two carbon piles "E," Fig. *194*, is inserted in series with the lamp circuits.

The resistance of a carbon pile varies with the pressure on that pile; a high pressure will reduce its resistance and a low pressure, allowing the carbons to spring apart slightly, will increase the resistance of the pile Therefore, the resistance of the two carbon piles "E" will depend upon the pressure exerted by the lever arm (20, 148, Fig. 194 shown herewith), on the pressure plate (7074, same Fig.) at the end of each carbon pile. A high pressure on these carbons will mean low resistance and low voltage drop in the lamp regulator (possibly two volts) which would correspond to a generator voltage of 34 volts. The two volts absorbed in the lamp resistance would then reduce the generator voltage to 32 volts, which is normal lamp voltage.

With the generator voltage at a maximum of 39 volts for lead batteries or 42.5 volts for Edison batteries, the operating magnet "T" will release the pressure on the carbons, so that the high resistance of the carbon piles will then absorb 7 volts excess with lead batteries and 10.5 volts excess with Edison batteries, reducing the generator voltage in each case to 32 volts normal.

When the generator is in operation current for the lamps branches off from the "+B" terminal on the upper right hand corner of the generator regulator and passes through the "+B" terminal at the bottom of the lamp regulator "+B" terminal at the top of the same panel and thence through the carbon piles "E" from left to right to "L" terminal of the top panel. From this point the operating circuit of the regulator branches off and continues through the regulating coil to the "—L" terminal, which in turn is connected to the generator negative. Current for the lamps continues from "+L" terminal to the lamp switchboard, through the various lamp circuits to the negative "G" terminal at the upper left hand corner of the generator regulator panel. (See Fig. 191.)

It will be noted that the operating magnet "T" of the lamp regulator is connected directly across the lamp terminals, connecting on the positive side at "+L" and on the negative side directly to the negative bus bar of the switchboard on standard Safety equipments. On some roads it is the practice to make this negative connection to each lamp circuit negative. This has the objection, however, that it makes a common negative return on all light circuits and a ground one one circuit will affect all and it will be very hard to locate the trouble. This negative connection is made outside of the circuit switches so that if all switches are open, as in daylight run, there is no current flowing through the regulator coil and resistance unit. Since connection is made directly to the lamp circuits all fluctuations in lamp voltage are received directly on the operating magnet "T" of the lamp regulator.

Assuming the regulator be properly adjusted for a lamp voltage of 30 volts, any change in conditions which tends to impress a higher voltage on the lamps will tend to force more current through the operating coil of the regulator. This increase in current through the coil will increase its magnetic pull on the pivoted armature "U," Fig. *194*, pulling it to the left and this movement being transmitted through the lever 20148, Fig. *194*, releases the pressure on the carbon pile "E." This release of pressure increases the resistance of both piles and the voltage drop of the lamp current flowing through the carbon piles is correspondingly increased; this increase in resistance drop in the carbons compensates for the momentary rise in the voltage, reducing the lamp voltage again to normal value. When the lamp voltage is brought back to normal the voltage across the terminals of the regulating coil of the lamp regulator will also be brought to normal, or more correctly, the lamp voltage will be brought to such a value that the magnetic pull of the operating solenoid will balance the pull of the adjusting spring of the rod "L," Fig. *195*.

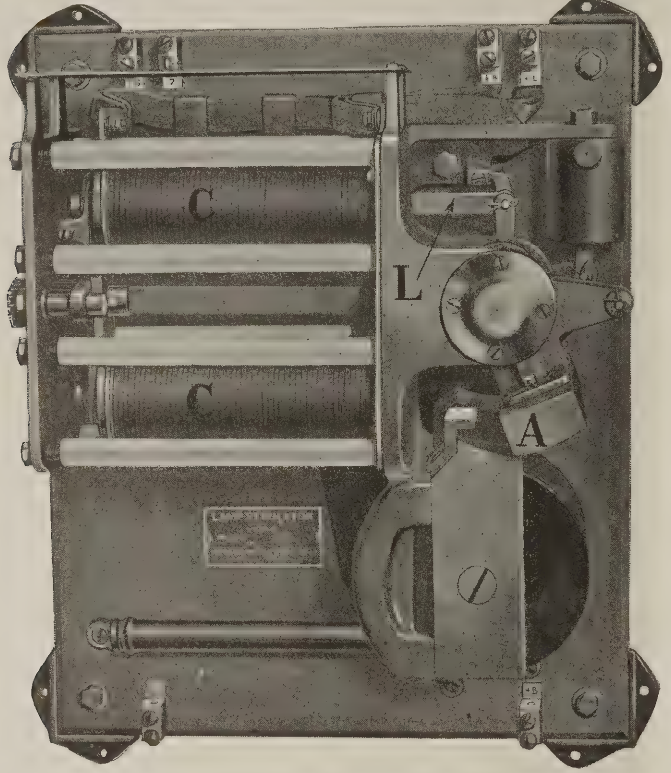


Fig. 195. Safety Type "F" Lamp Regulator; "C" Carbons; "L" Rod Connecting to Adjustable Spring; "A" Pivoted Magnet Armature.

When the generator voltage is at maximum value the lamp regulator carbon piles must have a maximum resistance. This requires that the pressure on these piles be greatly reduced. This means that the lever 20148 must be moved a considerable distance to the left, and in order to do this the magnetic pull of the operating magnet "T" must be sufficient to draw the armature "U" to the left to correspond with the movement of this lever and at the same time the tension on the spring opposing the magnetic pull will be increased by a similar amount. It is a well known principle in spring balances that the extension of a spring is directly proportional to the weight or pressure applied. So for an increase in tension, or "extension," there must be a corresponding increase in the force of the magnetic pull to produce a balance. The iron yoke of the operating solenoid and the armature "U," Fig. *194*, are so designed, however, that as the armature "U" is drawn to the left on increase in voltage, it decreases the air gap through which the magnetic lines must pass, and so the magnetism of the coil is automatically increased because of this fact and provides the increase in magnetic pull necessary to overcome the increase in spring tension which requires a slight increase in normal voltage.

This feature of the design has been so carefully worked out that if the carbon pile be cut out of circuit and we have a constant voltage on the operating solenoid, the armature "U" will balance at any point in its stroke, indicating a perfect balance at all times between magnetic pull and spring tension.

If the lamp voltage drops below normal the magnetic pull of the operating magnet "T" on the armature "U" is slightly reduced and this allows the spring to further compress the carbons "EE," reducing their resistance and this reduces the voltage absorbed in the carbon pile, raising the lamp voltage to normal value. This rise in lamp voltage also increases the current through the operating solenoid "T" until a balance is again obtained between the magnetic pull and the pull of the spring.

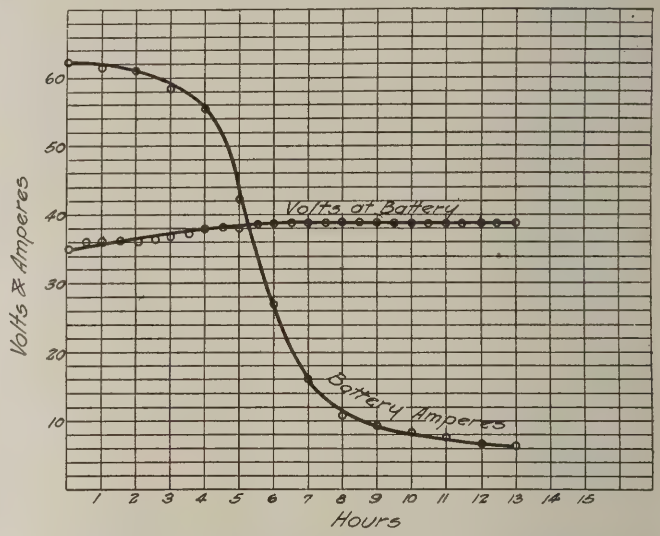


Fig. 196. Showing Variation of Battery Current and Axle Generator Voltage Throughout a Complete Charge of the Battery by Safety Type 'F' Equipment.

Replacement of Parts

Dynamo Regulator Voltage Coil.

To remove the voltage regulator coil, first take off the resistance unit "N," Fig. *193*, and disconnect both coils; disconnect the plungers of both coils from their guide levers by removing the two guide pins, then remove the two machine screws which secure the top supporting bracket to the slate base; then take out the 8 cap screws from the top of the bracket and then remove the bracket itself. Next take out the 8 cap screws which secure the bottom coil heads to the supporting frame. By tilting the series coil "S" slightly to the front, the voltage coil "A" can be removed complete with the top end, bottom heads, insulating washers and brass retaining tube, the latter being screwed into the top and soldered at both top and bottom. These are supplied as a single unit by the manufacturer. To apply a new coil, reverse the above operations.

Series Regulating Coil.

Disconnect the coil "S," then disconnect (the plungers of both) coils from their guide levers by removing the two pins; remove the two machine screws which secure the top and supporting bracket to the slate base, then the 8 cap screws from the top of the bracket, then the bracket itself. Next take out the 4 cap screws which secure the bottom coil head to the iron supporting frame, then unscrew the top coil head and insulating washer and take off the coil with bottom head and the tube complete. The bottom head and tube are soldered together and are removable from the coil, accordingly the series coils are supplied without heads, insulating washers or tubes. To apply a new coil reverse the above operations.

Automatic Switch.

To apply new coils, remove the switch and frame complete from the panel by disconnecting the top terminals of the heavy coil, both terminals of the fine wire or lifting coil, and the top terminal of the series regulating coil from the lower terminal block on the automatic switch frame. Take out the 3 machine screws which secure the automatic switch frame to the slate base and remove the switch complete.

To dismantle the switch proceed as follows:

Remove the magnet armature and laminated conductor complete by taking out the terminal screw at the left end of the flexible lead. Then remove the pin on which the armature is pivoted. In case of trouble with the automatic switch contacts the movable iron armature and the laminated conductor can be removed and replaced without taking the complete switch off the board. Next loosen the small set screw which passes through the top of the magnet yoke (at the front of the yoke) and prevents the iron core from turning. Then unscrew the iron core from the magnet yoke and remove it from the coils. The lower terminal of the heavy coil can then be disconnected from its terminal block and both coils removed as a unit. To reassemble the switch, reverse the above operation. The bottom of the core, the contact block and top carbon contact should all be on the same horizontal line. This is necessary to insure proper wipe of the brush. After the switch has been replaced on the board it must be tested (and adjusted if necessary) so that it will close at 34 volts. Adjustment is made by loosening the small set screw at the left end of the pivoted iron armature of the switch; be sure to lock the adjustment when correct, with the lock nut.

All unnecessary tampering with the switch and its adjustments must be avoided.

Field Carbon Pile.

To inspect the field carbon pile, or to apply a new pile, remove the four screws which hold in place the carbon cover and remove this cover. The front insulating rod at top can then be removed and the whole carbon pile removed if necessary. In applying a new carbon pile the number of discs must be such as to give a separation of about 1/64 in. (the thickness of one carbon disc) between the projecting "fingers" of the regulator lever arms "M" and "P." The number of discs per pile is approximately 168, but owing to variation in thickness a greater or lesser number may be required to give the proper separation between levers, which is the important point to look out for. In last month's lesson we stated this separation should be 1/32 in.; this was an error.

Lamp Regulator Coil.

To remove the operating coils of the lamp regulator disconnect its leads and remove the center screw (7487). Hold the coil firmly in place while taking out the center screw, then take out the coil complete with the insulating washers, brass tube and iron core. To apply a new coil reverse the above operations, making certain that the coil is wedged into the core and the center screw is drawn up as tight as it will go. These coils are furnished complete with brass tube and insulating washers, but without the iron core which is removable.

Lamp Carbon Piles.

To remove the carbon piles it is necessary only to take out the insulating rod at the top front of each pile by loosening the retaining screw at the left end of each rod to be removed. Hold the rods while loosening these screws, as the screws engage only the ends of the rods, and the latter are damaged when allowed to fall. These tubes are made of "Lavite," with an iron rod in the center, but a cracked or broken tube will prevent proper operation of the carbon pile.

Practical Stunts

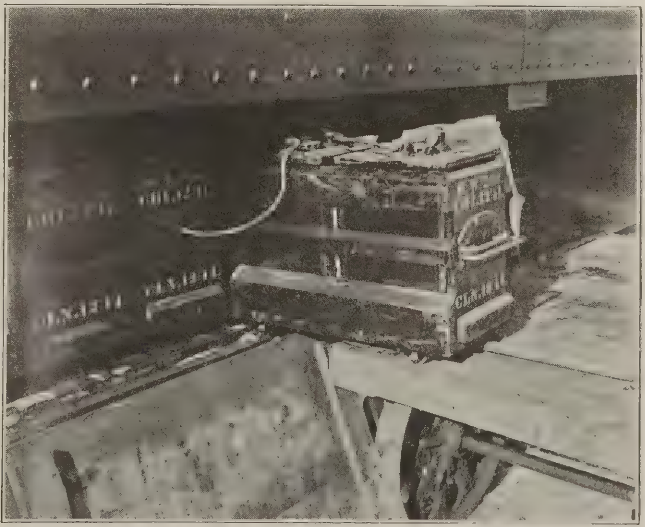
We Pay a Dollar Apiece for Practical Stunts—Send in Your Ideas

New Battery Tray

As every railroad car lighting man knows, the wooden trays encasing the lead battery tanks are a frequent source of trouble, for the water used in flushing the batteries often slops over and soaks down between the wooden tray, petrolyte filling compound and the lead tank. When the wooden tray, which is only about ⅜-in. thick, becomes soaked with water and acid, and with a blow hole or crack in the petrolyte filling compound, this makes a direct connection to ground. If there is a similar ground on another cell nearer to the negative terminal, the lead lining of the tank will be oxidized by the action of the leakage current flowing, and the tank will pit at this point, causing it to leak, and further increase the ground; in some cases the tank becomes pitted so badly that the electrolyte is completely drained off the cell, causing an open circuit of the battery.

It has been found that in one railroad terminal coach yard handling about 70 cars per day, there is an average of 1½ leaky tanks per day. This requires constant inspection and the removal of leaky cells before they cause serious trouble.

In order to reduce troubles of this sort a new battery tray has been designed by Mr. Bert Pachaly, electrical foreman at the Chicago coach yards of the Chicago, Rock



Battery with New Crate Type Tray Partially Removed to Show Construction.

Island & Pacific Ry. The tray is made up of heavy ⅞-in. pine boards with heavier pieces 1⅜-in. thick, which act as spacing blocks. These spacing blocks are placed one at bottom on the left side and the other at the top on the right side, facing the forward end of the tray. The tray is made as an open crate with solid ends and wooden strips on the sides, as shown, leaving an open space of 2½ inches between each side strip. The widths of the side strips are as follows: Top, 3-in; middle, 2-in, and bottom, 4-in. wide. The tanks are simply set down into this crate without any petrolyte filling compound whatever, and this, accordingly, eliminates the expense of filling compound and the trouble of installing and removing tanks. A slight clearance about ¼ in. is left between the top of the tray and the under side of the projecting edge of the lead tank, the entire weight of the elements being carried at the bottom. There is a double partition between the two cells of each tray and a space of about ⅝ in. is left between the two boards of this partition. The bottom of the tray is grooved, so as to allow all water used in washing off the battery to drain off. There are 3 grooves crosswise and 3 grooves lengthwise of the tray under each tank. The grooves are ¼-in. wide and about ¼-in. deep. There is a ¾-in. piece at the front and back which acts as a buffer. A steel angle iron 1¼ in. by ½ in. and 4¾ in. long of ⅛-in. stock is placed on the bottom front corner of the tray so that a crowbar can be used in handling batteries.

This tray can be kept clean and free from acid by washing it off with a hose every month or two. When the inspector finds the battery looking dirty and covered with acid spray, he can simply turn the hose on it and give it a thorough cleaning. The wooden crates are painted with P. & B. paint before installing the tanks, so as to prevent the wood from soaking up water and acid, as far as possible. Although porcelain rollers are used on the tray showin in this illustration, these will be replaced with porcelain skids, as it is found that with the constant vibration of car motion the rollers soon cut their way down into the wooden floor of the battery compartment, until the side irons of the roller frame rest on the floor.

Exciter Lamp Trouble.

Like a good many other fellows I sometimes do things wrong and once in a while I am not afraid to admit it.

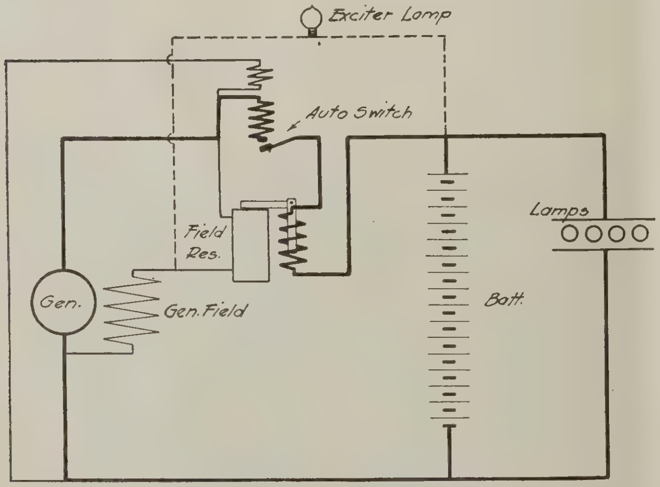


Fig. 1. The Wrong Way to Connect in an Exciter Lamp.

I thought that a certain axle lighting equipment was giving some trouble on account of losing its residual magnetism and failing to build up, so I installed an exciter lamp. Instead of connecting this between positive battery and positive generator, as shown dotted in the diagram, Fig. 2, it seemed to me the most natural thing in the world to connect direct from battery to positive field like Fig. 1 in order to put battery current through the generator field when the equipment was dead—but there's where I made my mistake.

Everything went fine until the train speed got above 40 miles an hour; at that value the generator field resistance was all cut in, and when the train speed got about 60 miles an hour the main fuse blew. Meanwhile the lamp voltage had gone away above normal.

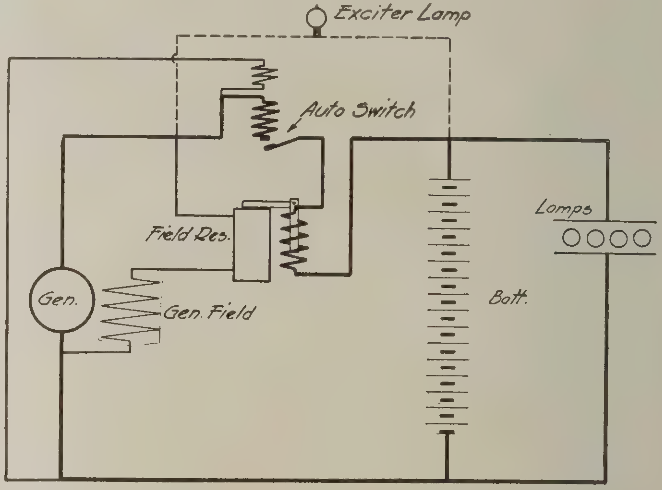


Fig. 2. Proper Connections for Generator Field Exciter Lamp.

I was going to send this in to the question box, but I've got it all figured out myself. If you'll look at the diagram, Fig. 1, you will see that I had the exciter lamp connected directly from positive battery to positive field. After the automatic switch closed this placed the exciter lamp in parallel with the generator field resistance. Now the exciter lamp was an 8 cp. carbon and represented about 40 ohms resistance. When the field resistance was all in it had a resistance of about 40 ohms and this in parallel with the exciter lamp resistance of 40 ohms gave a joint resistance of only 20 ohms. This, then, is the maximum amount of resistance the regulator could insert in the field circuit with the exciter lamp so connected.

When the car was traveling at 40 miles per hour it apparently required 20 ohms field resistance to control the voltage, for at this speed the exciter lamp would force the regulator to cut in all its resistance.

This was the limit of regulation so when the train speed went above 40 miles the generator voltage increased rapidly till at about 60 miles, when the main fuse blew.
H. K. F.

Emergency Car Lighting.

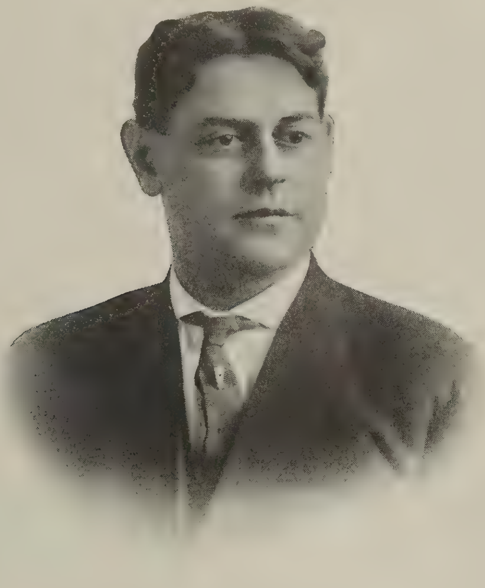
When a belt is lost, or a fuse blown, the batteries often arrive at the terminal so exhausted that the car is dark. When there is no time to change batteries and the car has no train line, the repairmen are up against it. Having had to handle such cases numerous times I found that by having a pair of leads, consisting of ordinary lamp cord, with an attachment plug on each end, I could remove the lamp in the vestibule of the dark car, plug in one end of the extension cord and connecting the other into the vestibule lamp socket of the next adjoining car.

Before doing this, it is necessary to open the battery switch in the dead car and cut all the circuits except the center lights, limiting the current to ten amperes, otherwise the fuse in the platform circuit on the good car will blow.

When the car starts, cut out the connection.—A. B. M.

E. Wanamaker

Mr. E. Wanamaker was born in Missouri and as a boy spent his time in bothering railroad men and contractors in an endeavor to learn the practical side of engineering. When old enough, he entered the employ of various operating and contracting concerns and finally, at the age of 18, secured a position with the Western Telephone and Telegraph Co. After about two years in this work he was appointed line foreman for the Colorado Power Company at Canyon City and Cripple Creek at the time when Cripple Creek was the largest gold mining camp in the world. He then served about three years at sea as a marine engineer, and before quitting the sea was awarded a second engineer's certificate.



Mr. E. Wanamaker.

At the age of about 24, he entered the employ of the U. S. Reclamation Service in connection with the work of driving the Gunnison tunnel in Colorado and was soon appointed superintendent of power and machinery. This tunnel is six miles long and diverts the Gunnison river from the Black Canyon of the Gunnison into the fertile but previously arid valley of the Uncompahgre river. Pioneer methods were employed in driving this tunnel, both on account of its extreme length and also on account of the fact that it was the first big tunnel in the United States in which electric power was used for everything except the air drills.

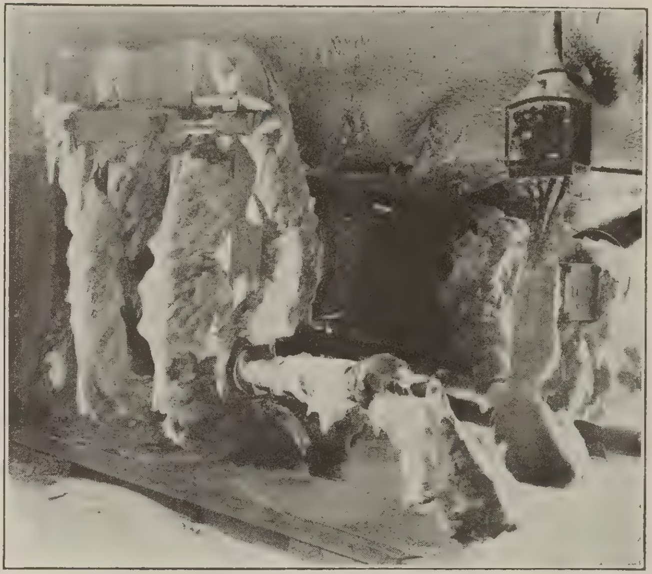
After three years' work on the Gunnison tunnel, in which he had charge of all mechanical and electrical equipment, Mr. Wanamaker entered the employ of the Arnold Company of Chicago. With this company he spent several years as engineer and superintendent of construction, engaged in the construction of railroad repair shops, power plants, electric railways, hydroelectric power plants, etc. During this time the new Frisco shops at Springfield, Mo., were built and here he was superintendent of temporary construction and had charge of the installation of all electrical and mechanical machinery. A record was made on the installation of the electrical and mechanical equipment on this job, all machinery and electric wiring being installed within a period of 60 days. For the greater part of the tme there were over 120 electricians employed on the work.

For the past year and a half Mr. Wanamaker has been chief engineer of the Rock Island Lines at the main shops of the company at Silvis, Ill. He received his present appointment as electrical engineer for the Rock Island R. R. December 1st, 1914, and now has charge of all electric lighting and power equipment in railroad shops, car lighting, etc.

Car Lighting Man's Job in the Winter Time

Few appreciate the difficulties which the car lighting inspector has to contend with in the winter time, but the accompanying illustration gives some idea of the situation. What would a stationary plant engineer think of his job if he came down some winter morning and found his generator buried in ice with the belt off and everything out in the open at about 20 degrees below zero?

Every axle generator car lighting system is a little complete central station in itself and one that operates automatically, taking care of itself with what assistance the terminal electrician can give it.



Showing Collection of Ice on Generator Suspension and Axle Generator. Note the Heavy Cakes Which Have Collected on the Generator Leads.

One lesson that can be learned from the accompanying illustration is that the generator cables either in canvas covering or hung loose, as shown in this instance, seem to collect great cakes of snow and ice, these frequently weighing 50 pounds or more. In installing cable terminals, this fact must be kept in mind so that the vibration and swaying under this heavy weight of ice will not tear the cables loose and cause a generator failure. Incidentally, the armor braided three conductor cable described under the manufacturers' section in this issue may be of interest in this connection.

Chinese Chief Electrician Visits U. S.

Mr. Chan Y Hoey, chief electrician of the Peking & Mukden Railway visited numerous American manufacturing plants and railroad terminals in this country on his return to China from an extended visit in England.

Mr. Hoey has charge of all electrical work on the Peking and Mukden Ry., a line 720 miles in length and operating about 100 electric lighted cars which are equipped with the Stone axle system. He also has charge of the electrical equipment of the locomotive repair shops, which, however, at the present time have only 150 h. p. in direct current motors. Two turbogenerators sets of 250 kw. each have been installed to provide for future extensions. He states that railroad matters are developing very rapidly in China, and the object of his visit to occidental countries has been entirely for the purpose of learning the best practice in electrical equipment on the railroads of Europe and America. Mr. Hoey has promised to submit articles occasionally on the developments in China which will no doubt be of interest to our readers.

With the Manufacturers

New Armored Cables for Car Lighting

As every railroad yard electrician knows, battery yard charging leads wear out rapidly. This is undoubtedly due both to the wear and tear of being dragged around on the ground and also to the fact that they are frequently run over by commissary trucks and the insulation damaged. An armored cable has recently been put on the market by the Okonite Company which is specially designed to meet these severe conditions. It consists of a two conductor cable, either of No. 4 or No. 6 size, each wire made up of 61 strands so as to be very flexible. Each conductor is insulated with Okonite and is covered with a heavy braid; sufficient jute is added as packing to fill out the section around the two wires and make the cable round.

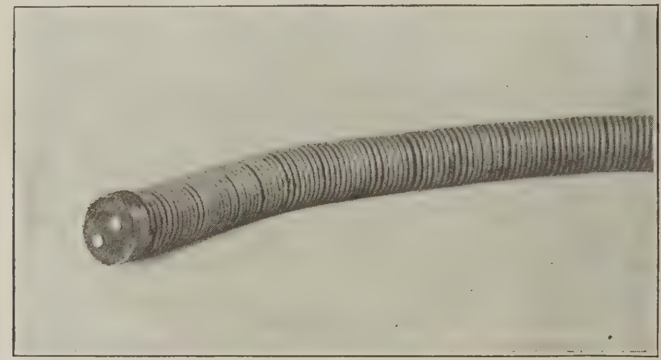


Fig. 1. Two-Conductor Wire Armored Yard Charging Cable.

Two heavy braids thoroughly saturated with a weather-proofing compound are then woven outside of this and the whole cable is solidly wound with a single strand of No. 14 BWG galvanized iron wire. This gives a cable which is sufficiently flexible and at the same time has excellent wearing properties and can stand being run over with a truck occasionally without serious damage to the insulation.

Axle Generator Cable.

It has been past practice in car lighting to encase the cables connecting the axle generator mounted on the truck, with terminal condulet mounted on the car in a canvas or other type of cloth tubing. In the winter months it has been found that the irregular surface of this loose canvas tubing serves to collect ice and snow and at the same time the abrasive action of the wires inside the tubing rubbing together with the constant vibration of car motion wears out the insulation of the connecting leads which have been drawn loosely inside of it. Often three separate wires are run from the terminal condulet on the car to the generator, but these collect ice more rapidly than a single cable.

In order to eliminate the troubles arising from this source the Okonite Company has recently put on the market a special cable designed for this purpose, as shown in Fig. 2. It consists of a three wire cable, two No. 6 conductors, each made up of 271 strands, and one No. 10 conductor made up of 61 strands, all insulated with Okonite insulation. Sufficient jute is added, as shown in Fig. 3, to make the cable round, and this is then covered with a heavy double braid saturated in a weather-proofing compound. Outside of this is woven a galvanized steel wire covering. This

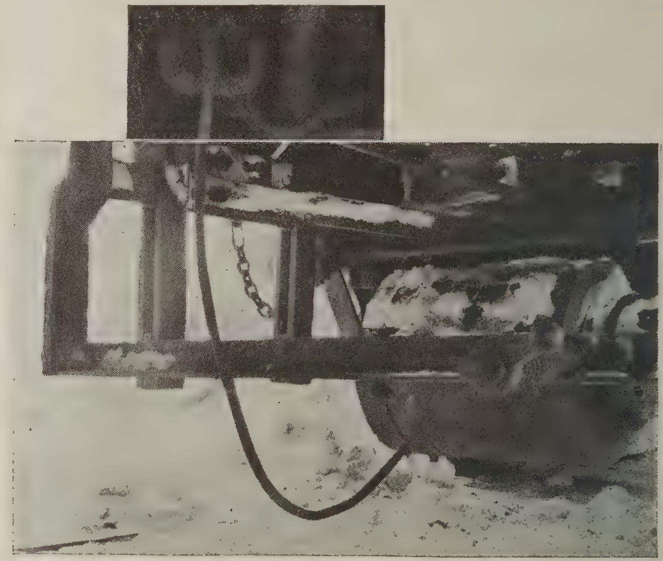


Fig. 2. Special Three-Conductor Armored Cable for Axle Generator. Note the Cable Support Above.

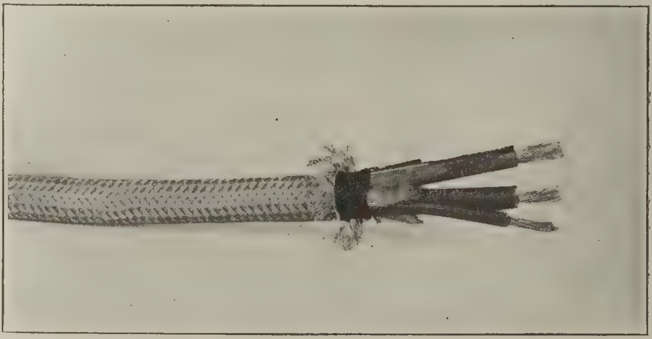


Fig. 3. View Showing the Detail Construction of Armored Cable for Axle Generator Leads. Cable Is Protected by Woven Steel Wire Armor.

is made up, as shown in Fig. 3, in basket weave form, each strand of the weave consisting of seven very small galvanized steel wires of about No. 36 BWG gauge, laid side by side, as shown. This gives an armor of steel which is both very flexible and provides a fairly smooth covering, which offers no projecting fibers or dented surfaces for the snow and ice to adhere to. The swaying of the car motion seems to create enough movement in the cable armor to keep it entirely free from snow and ice, as is shown in the accompanying illustration, Fig. 2.

Samples of either of these cables will be sent to any railroad chief electrician or electrical foreman upon request to the Okonite Co., New York, or the Central Electric Co., Western Agents, Chicago, Ill.

Safety at Overhead Line Crossings

Considerable attention has been given lately to the matter of making high tension crossings safe. There are many such crossings of power lines over railroad right of way, telephone and telegraph lines and other power lines which require attention.

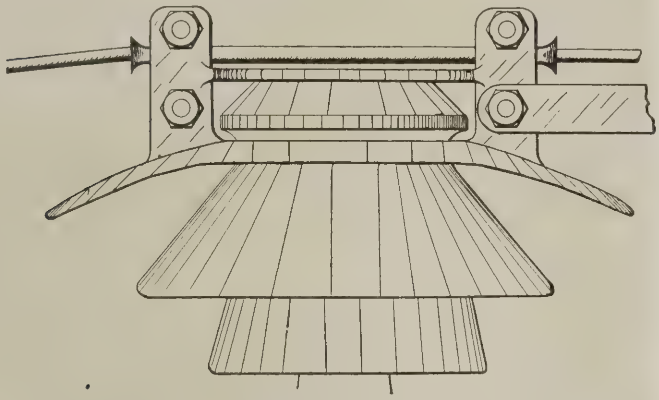


Fig. 1. Single Clamp With Arcing Shields.

The Clark Electric & Mfg. Co., 149 Broadway, New York, makes several clamps for use with single insulators and clamping sets for use with two insulators on double cross-arm construction for attaching lines efficiently to the insulators at these crossings.

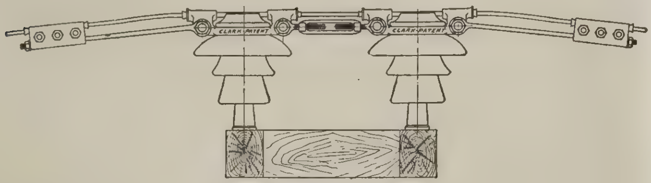


Fig. 2. Double Insulator of Rigid Construction With Outrigger Clamps.

Figure 1 shows a single clamp with arcing shields to protect the line on flashover and it is usual to use a bushing with this clamp.

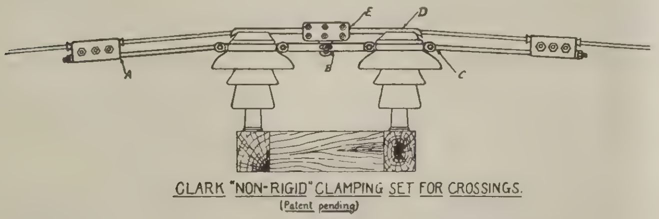


Fig. 3. Non-Rigid Clamping Set for Crossings.

Figure 2 shows a clamping set for more or less rigid construction and Figure 3 a set featuring flexibility. Neither of these sets depends upon a cemented cap for satisfactory operation, as experience has shown that such caps often work loose in service. In both sets attachment is made directly to the insulator and in both cases the line conductor may be broken before it can be pulled from the clamps and even in such severe service no injury is done the insulator.

Outrigger clamps are used with each set, so that should the line become fused at the insulator, due to a severe short circuit, it will still be held in place by these clamps. These clamping sets also act as shields, as they extend well out beyond both insulators and some part of the set is always beneath the conductor.

All parts are designed for high mechanical strength and the conductor and insulator are safeguarded in every possible way. Provision is made for a variation in distance between the insulator centers.

Under the Big Tent

Here is a slogan that has acquired a new meaning for the Willard Storage Battery Co. Incidentally, it offers a fine testimonial to the ingenuity of enterprising American manufacturers when it comes to solving a knotty problem in a hurry.

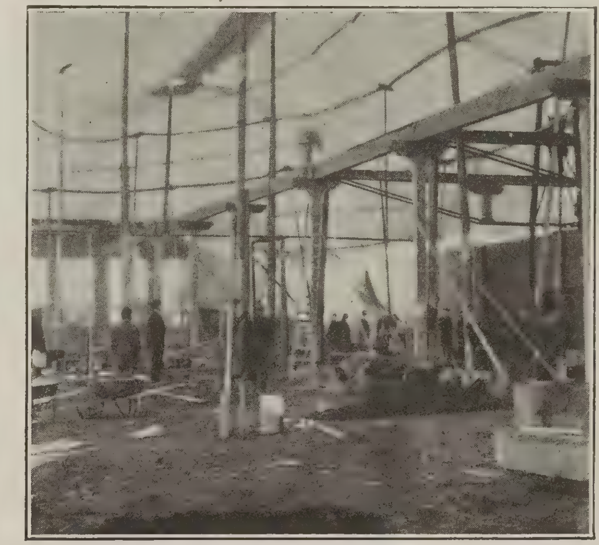


Fig. 1. Interior of the "Willard" Big Tent With Steam Pipes Installed to Prevent Freezing of Mortar and Concrete.

The tent is out at 280 E. 131st Street, Cleveland, and if you look under it you'll find 570 workmen, erecting a big brick building! You see, it's quite some tent—300 feet long, 30 feet high and 100 feet wide, to be exact. Its 5000 square yards of canvas have kept off wind, frost,

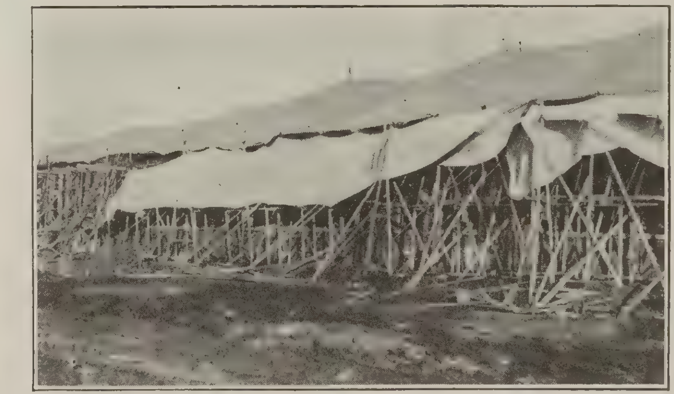


Fig. 2. Exterior of the Tent Showing Construction Staging. This Gives an Idea of the Size of the Work.

"The House

Your entire requisition for electrical supplies with one order and you receive the goods in

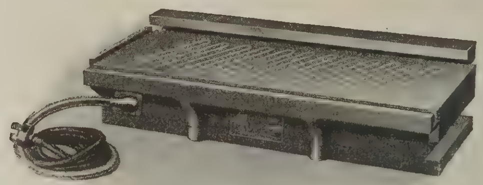
Alberyl Bowls

and glassware, for semi-indirect car-lighting, office and station lighting.

ALBERYL SHADES are made in pleasing and efficient designs.

Ask us about **ALBERYL.**

D. & W. Magnetic Chucks



Heat, Oil and Waterproot Chucks for Every Purpose

There's a D. & W. Magnetic Chuck to meet your requirements—flat, vertical and rotary styles, proof against moisture, oil and heat. Holding power greater than ever before secured in magnetic chucks of equal size. Wide capacity, true and accurate in operation, holding heavy work rigidly and light pieces without distortion. Provided also with auxiliary plates to be used as fixtures in holding odd shapes, etc.

Send for complete information.

"D. & W." Chuck Coils are wound with "Deltabeston" (asbestos covered) magnet wire, and coil units are interchangeable.

Central Electric Company

320-326 So. Fifth Avenue Chicago

of Service"

on any job, no matter how large, can be covered one shipment. Think of the convenience!

OKONITE

TRADE MARK.

Insulated wire for railway signals, car lighting, shop and terminal light and power service must be absolutely dependable and have the highest insulating qualities — this is just another way of specifying Okonite. It has for years been the standard in railway service.

Okonite Insulation contains never less than 30% of the best quality dry, fine, up-river Para rubber and is made in but one grade, only—**The Best.**

The "Maxolite"

Designed for that railroad electrical engineer who demands greatest efficiency, ease of installation and a gas and waterproof fixture built in

One Piece

It is well ventilated for use with Type "C" Mazdas. With the Type "R" Fitting, makes it possible for a one-armed man to install it. Specially adapted for,

Shops	**Trainsheds**
Yards	**Roundhouses**
Platforms	**Warehouses**

Ask for Bulletin No. 43

Central Electric Company

320-326 So. Fifth Avenue Chicago

rain, and snow, while the Willard Company has been erecting a full-sized factory building in twenty days' time. Temporary steam pipes laid against the brick walls assure quick drying, and the men are working in three shifts.

The building was started on January 10, to be completed February 1. It is the third building to be erected on the new 10-acre site of the company. These will be occupied immediately, but the construction work will continue until, by the first of January 1916, there will be fourteen buildings completed and occupied.

Although one of a group, the speedy completion of this particular building was necessary to handle the rapidly increasing production of train lighting and automobile batteries.

General Lead Batteries Company.

Due to the existence of a battery jar marketed under the name "Titan" and the fact that any battery using these jars might appear as a Titan battery, the Titan Storage Battery Company of Newark has changed its name to the General Lead Batteries Company.

No change whatever in ownership, officers or policy is involved. The change is made entirely to avoid confusion.

New English-German Technical Dictionary.

There has recently been put on the market a new English-German dictionary written to meet the needs of an engineer who has a reading knowledge of German. This dictionary contains all the technical terms in common use in either language and should be very useful in translating technical literature from one language to another. It is published by the C. N. Caspar Company, of Milwaukee.

Committees

of the Association of Railway Electrical Engineers

President
H. C. Meloy, Lake Shore & Michigan Southern Ry.
Senior Vice President
E. W. Jansen, Illinois Central R. R.
Junior Vice President
C. J. Causland, Penn. R. R.
Secretary-Treasurer
J. A. Andreucetti, Chicago & North Western Ry.
Executive Committee
W. A. Del Mar, New York Central Lines.
J. E. Gardner, Chicago, Burlington & Quincy R. R.
J. J. Hack, Southern Pacific Ry.
J. L. Minick, Penn. R. R.
L. S. Billau, Baltimore & Ohio R. R.
L. C. Hensel, Frisco Lines.
COMMITTEE ON METAL CONDUIT SPECIFICATIONS
J. L. Minick, Chairman, Foreman, Penn. R. R.
COMMITTEE ON STANDARDIZATION OF CRANE, TURN TABLE AND TRANSFER TABLE MOTORS
H. C. Meloy, Chairman, Chief Elec., L. S. & M. S. Ry.
COMMITTEE ON WIRELESS TELEPHONE AND TELEGRAPH AS APPLIED TO MOVING TRAINS
Dr. Frederick Millener, Chairman, Custodian of Term., N. P. Ry.
COMMITTEE ON POWER PLANT OPERATION
J. H. Davis, Chairman, Elec. Engr., B. & O. R. R.
COMMITTEE ON COMPRESSED AIR GENERATORS
L. C. Hensel, Chairman, Chief. Elec., 'Frisco Lines.
COMMITTEE ON STANDARD RULES FOR CAR WIRING
Geo. B. Colgrove, Chairman, Chief Elec., Ill. Cent. R. R.
COMMITTEE ON STANDARDS FOR TRAIN LIGHTING EQUIPMENT
D. J. Cartwright, Chairman, Elec. Engr., Lehigh Valley.
COMMITTEE ON SHOP PRACTICE
D. C. Wilson, Chairman, Elec. Engr., Union Pac. Ry.
COMMITTEE ON ELECTRIC HEAD LIGHTS
E. W. Jansen, Chairman, Elec. Engr., Ill. Cent. R. R.
COMMITTEE ON DATA AND INFORMATION
Edw. Wray, Chairman, RAILWAY ELECTRICAL ENGINEER.
COMMITTEE ON SPECIFICATIONS FOR WIRE CROSSING FOR POTENTIALS ABOVE 100 VOLTS
J. R. Sloan, Chairman, Engr. Elec. Car Stg., Penn. R. R.
COMMITTEE ON INDUSTRIAL TRUCKS
T. V. Buckwalter, Mech. Dept., Penn. R. R.
COMMITTEE ON RECIPROCAL RELATIONS
L. S. Billau, Elec. Dept., B. & O. R. R.
COMMITTEE ON LOOSE LEAF BINDERS
J. R. Sloan, Engr. Elec. Car Stg., Penn. R. R.
COMMITTEE ON ILLUMINATION
L. S. Billau, Elec. Dept., B. & O. R. R.
COMMITTEE ON WIRE SPECIFICATIONS
Wm. A. Del Mar, Chairman, Asst. Engr., N. Y. Central Lines.

LOOK FOR THE MARK
E
ON ALL TYPES OF
ELECTRIC TRAIN-LIGHTING REPAIR PARTS
IT STANDS FOR
OLIVER QUALITY
AND
EFFICIENCY
ARMATURES, FIELDS AND SWITCH COILS
REPAIRED AND REWOUND
OLIVER ELECTRIC & MFG. CO.
2217-19-21 LUCAS AVE. ST. LOUIS, MO.

RAILWAY
ELECTRICAL ENGINEER

Official Journal
of the Association of Railway Electrical Engineers.

PUBLISHED MONTHLY BY

WRAY PUBLISHING CO.

EDWARD WRAY,
President.
C. D. SPERRY.
Assoc. Editor.

ADVERTISING BLDG.—123 W. MADISON ST.
CHICAGO.
Telephone, Randolph 7414.

Entered as second-class matter, August 6, 1909, at the Post Office at Chicago, Ill., under the Act of March 3, 1879.

TERMS OF SUBSCRIPTION
United States, Canada and Mexico - - - Per Year, $1.00
Foreign - - - - - - - - - - Per Year, $1.50

Table of Contents

Page

Editorial:

The Head End Axle Lighting System..............301
Large Lift Bridge Operated by Remote Control........302
G. E. Exhibit at Panama Exhibition......................306
Three-Phase Italian Passenger Locomotives.............307

Railroad Electricians' Club:

Constant Potential Charging, By J. Lester Woodbridge 310
Lead Storage Battery Questions....................312
How Lead Batteries are Made.......................212
Shop Motor Section: Alternating Current Windings, By J. H. Wickman..315
A. B. C. Car Lighting Course: Lesson No. 38, Inspection of Safety Equipment...................................317
Practical Stunts 321
With the Manufacturers.................................323
Association Directory 326

The Head End Axle Lighting System

The use of a generator driven from the car axle and furnishing light for an entire train is by no means new, for as early as 1881 the London, Brighton & South Coast Ry. of England, employed a system for lighting their cars in which a dynamo was located in the guard's van (or baggage car) with the dynamo being driven from the car axle. This, by the way, was only two years after the development of the incandescent lamp itself by Mr. Edison. Many trains were so equipped in the following year and we are advised that several of these original equipments are still in operation on that railroad.

The use of single car axle lighting systems has been so extensively applied in this country that we are inclined to look upon the recent experiments on the Northern Pacific R. R. with a large axle driven generator mounted in the baggage car and furnishing the light for the entire train. as a new venture. Such is not the case, however, although all credit is due those engineers of the Northern Pacific R. R. and the Gould Coupler Company who have developed this system to its present state of perfection. The requirements of generator capacity, lamp voltage regulation and battery charging are far different from those of the early equipments mentioned.

This system, as fully described in our October, 1914, number, consists of a single 20 k.w. generator mounted on the floor of the baggage car directly over a jack shaft. The generator is driven by a Morse silent chain from the jack shaft, which in turn is chain driven from the forward axle of the forward truck, the brake beam being omitted from the wheels on this axle.

Seven units of 4 k.w. capacity have been in service since 1912 and one unit of 20 k.w. capacity has been in service since April, 1914. Thus the large capacity unit has successfully passed through the severe conditions of one winter and the seven smaller units have seen three years of service. In no case has serious trouble been experienced.

An automatic lamp regulator was installed in connection with the 20 k.w. system on November 30th, 1914, and since that date the equipment has run regularly without a train electrician or other attendant. All operation of the system en route is entirely automatic and the equipment is cared for only by terminal inspection, as is done with single car axle lighting systems. We are advised that the lamp regulator has given satisfactory regulation, controlling the lamp voltage within 2 per cent of the 66 volt normal, with a load variation of from 30 to 90 amperes. This lamp regulator is of the standard Gould simplex type, having a multiplier for intensifying the action of the main regulating solenoid.

In December, 1914, the steel case covering the horizontal chain running over the axle and counter shaft pinions was removed. This case was applied for the purpose of running the chain in a bath of oil and graphite. Upon removing it after eight months' service and noting the wear upon chain and pinions, it was observed that the pinions did not show any signs of wear while the chain seemed to be worn slightly, in fact to about the same extent as the chain between the jack shaft and generator, which had been running exposed. Both chains will now be allowed to run unprotected so that a broken chain might fall on the track instead of causing trouble.

The equipment does not seem to be in any way affected by ice, snow or other winter conditions and we are advised that a monthly saving of $260.00 is effected on each equipment. Additional machines of the larger type are on order and will soon be installed.

Thus has one progressive road of the west apparently solved the problem of replacing train electricians and steam driven generator sets which operate at low economy. The application of this system will probably be limited, however, to those roads who have been able to employ the steam driven head end system on block trains, which run as an unbroken unit from one terminus to the other. It would seem that as far as flexibility of operation is concerned, this system falls far short of the ideal found in the single car unit axle system, unless as one railroad official suggested, that all baggage cars on the system be equipped with a generator capable of lighting any train. In this case it is possible that the head end axle system might prove to be one sufficiently flexible and economical to warrant its use by roads who now find it impossible to use the steam driven head end sets.

Large Lift Bridge Operated by Remote Control

In many particulars the installation of the new Pennsylvania lift bridge at 19th St., Chicago, is of novel and most interesting design as it is an unusually large bridge and the entire operation of the bridge is effected by remote control. It was decided to employ the vertical lift type bridge rather than the bascule type in this case, on account of the possibility of future grade elevations at this point, in which case the vertical lift type bridge would be of service both before, during and after elevation. The bridge is a double track one and is built unusually heavy.

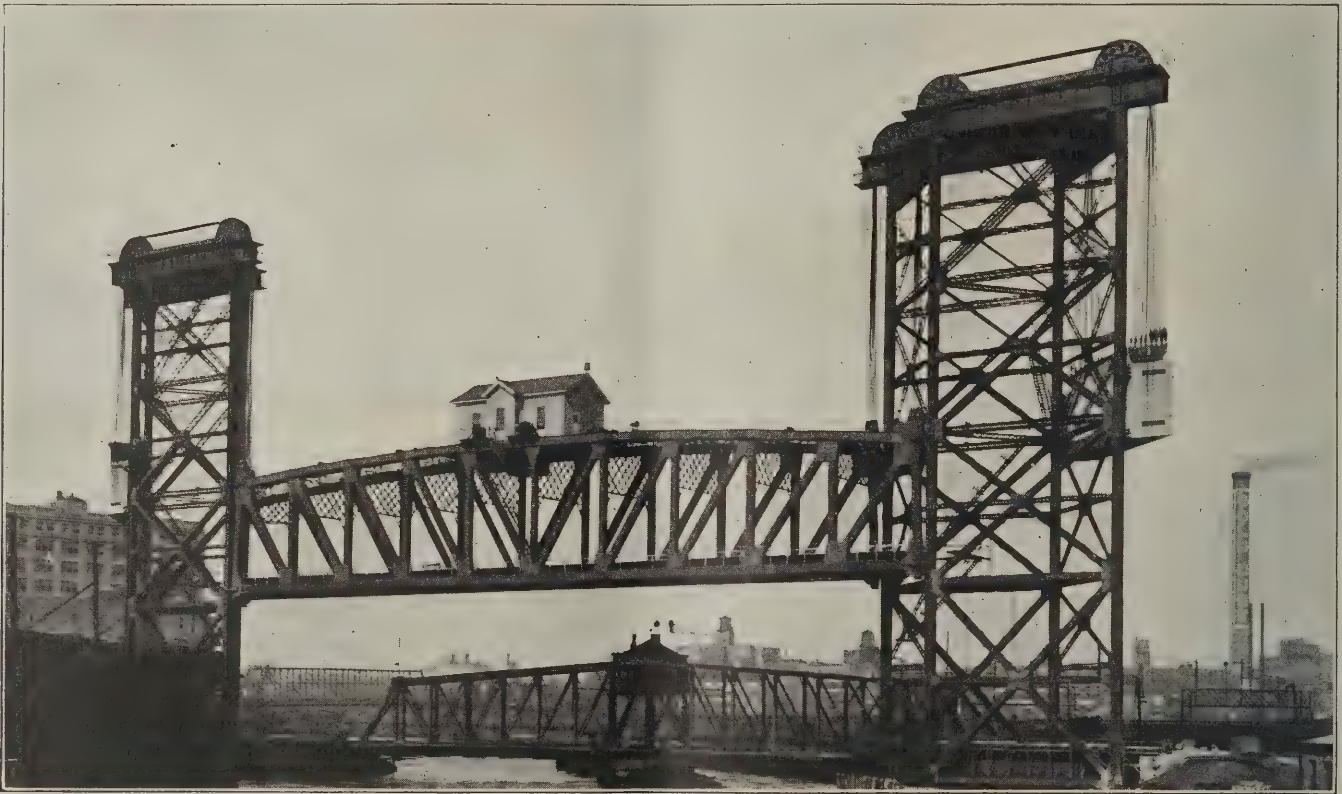


Fig. 1. Penn. R. R. Double Track Bridge at Chicago—Span, 272 ft.; Weight, 1675 tons; Supported by 16 2¼ in. Steel Cables at Each Corner and an 835 Ton Counterweight at Each End. Machinery House and Operator's Cabin Are Shown Mounted on Top of the Span.

The bridge is of 272 ft. span but the river is crossed on an angle of about 65 deg. so that the bridge is built on the skew and the clear channel is something less than this. The entire weight of the span (1,675 tons) is carried by two steel towers 160 ft. high, and is balanced by a great counterweight at each end, these being composed of a solid block of concrete, each weighing 837 tons. The counterweights and span are carried by sixteen 2¼-in. steel cables at each corner and these pass over great sheaves 15 ft. in diameter at the top of towers, as shown in Fig. 1. The vertical travel of the bridge is approximately 110 ft., the hoisting being accomplished by two large electric motors installed on the machinery house over the center of the bridge which drive four large drums, upon each of which two operating cables are wound

Battery House.

Power for operating the bridge is taken direct from a large station type Gould storage battery of 1,650 ampere hours capacity. 120 cells are provided which deliver a voltage of approximately 220 volts at the bridge motors. The storage battery is located in a small brick building adjacent to the bridge which was built specially for this purpose. The floor is of concrete covered with brick and this coated with a heavy layer of asphaltum compound to prevent acid action on the concrete. Five large ventilators are installed in the roof to remove all gases generated in battery operation.

The battery is charged on an off-peak-load contract basis by power furnished from the adjacent central station of the Commonwealth-Edison Company so a low rate as per schedule C* is obtained. This power is received at 220 volts, three-phase a. c. and is converted to d. c. for battery charging in one or both of the motor generator sets shown in Fig. 3.

The charging rate and period of charge to be given the battery daily have been worked out on the basis of assuming that 60 ampere hours are required for one complete lift, and 30 ampere hours for one partial lift, so that the battery operator coming to work in the morning and having a record of the number of both complete and partial lifts in the 24 hours previous, can tell from the chart both the charging rate and the length of time which must be employed for charging the battery.

Power is purchased on a maximum demand basis so the charging rate is kept as low as is consistent with good efficiency in motor-generator sets. For instance, assuming 10 complete lifts and 5 partial lifts during the past 24 hours, the operator will charge at 90 amperes for 8 1/3 hours, etc. Current from the battery passes through the double pole circuit breaker on the switchboard in the battery house and thence through No. 1,000,000 C. M. cables underground to the stationary bridge trolley rails mounted vertically on one of the bridge towers as shown in Fig. 5.

---

*Schedule "C" of the Commonwealth Edison Co., Chicago, is based on five year contract as follows: Primary charge of $70.00 for the first 50 k.w. demand, 75c per k.w. demand in excess of this; no current to be used between the hours of 4:30 and 8:30 p. m. during winter months. Current charge is as follows: 5c for the first M, 3c for the next 4 M, 1.1c for the next 25 m., 0.9c for the next 70 M and 0.65c per k.w.hr. for all over 100 M k.w.hrs.

Bridge Trolley Rails.

These trolley rails consist of 3 in. T iron bars mounted vertically on one of the towers and on the flange of the T is riveted a heavy copper plate, this being riveted solidly every 6 in. with the rivet heads filed off to provide a smooth surface for the trolley shoe. The trolley shoe spreads over this copper surface with guides on each side and is held firmly against the rail by the adjustable spring mechanism, as shown. The links are pivoted rather loosely so that the trolley shoe may freely follow the trolley rails.

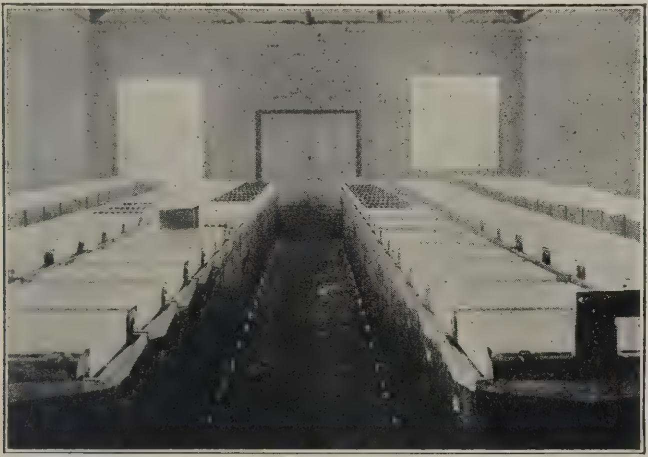


Fig. 2. Battery for Operating Bridge Consisting of 120 Gould Cells Having 1600 Ampere-Hour Capacity.

Control Mechanism.

Although power is carried direct from the bridge trolley rails to the remote control panel in the machinery house on the bridge, Fig. 7, a certain definite procedure must be followed before the bridge operator can make use of any of his control circuits in moving the bridge. This procedure is as follows:

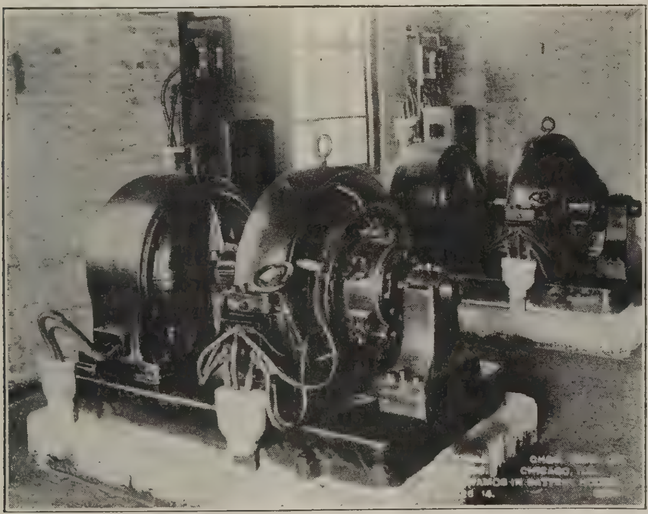


Fig. 3. 50 k.w. Motor-Generator Sets Which Supply Battery Charging Current.

(1) Tower man must set all signals at danger.

(2) It is then possible for the tower man to close a switch which allows the bridge operator to utilize his control circuits. This fact is indicated to the bridge operator by a red signal light

(3) Bridge operator then starts his rail-lock motors by means of the controller at the right hand side of Fig. 6 and these rail lock motors simultaneously draw the rail locks at each end of the bridge.

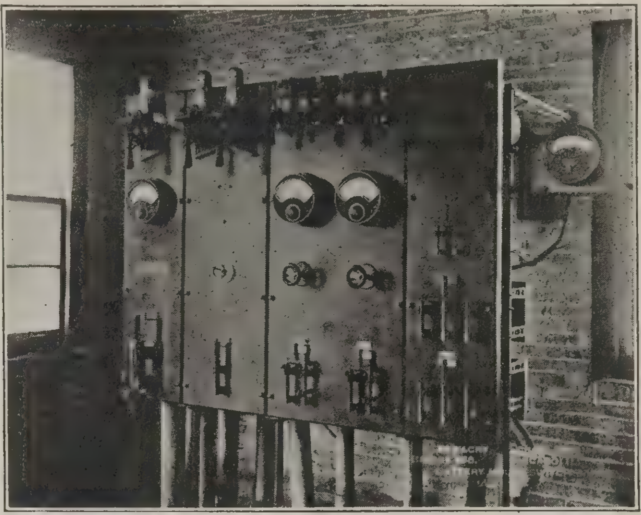


Fig. 4. Battery House Switchboard for Charging Battery.

(4) After all rail locks are completely drawn a contact is automatically made which completes the control circuits for the hoist motors, but until all rail locks are completely drawn it is impossible for the bridge operator to start the hoist motors.

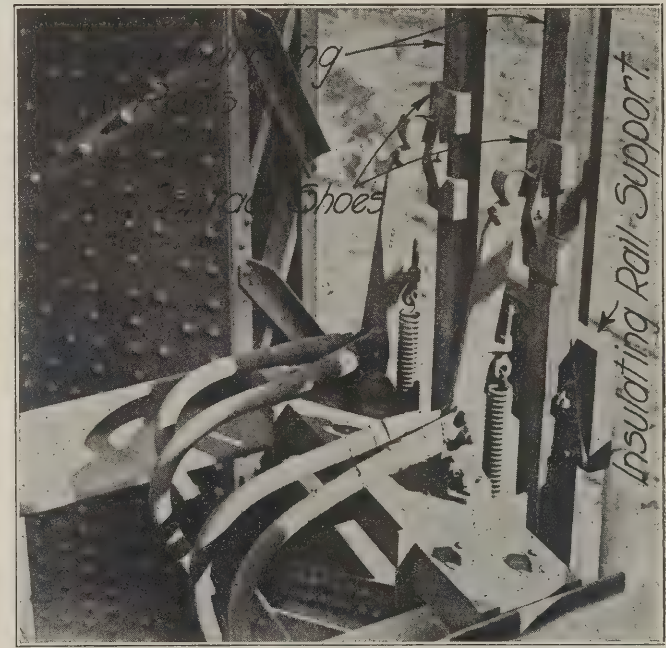


Fig. 5. Bridge Trolley Rails Showing the Method of Collecting the Current on the Bridge.

(5) The bridge is then free to move up or down at the will of the operator by throwing the control lever at the left hand side of Fig. 6.

(6) When the bridge gets within 15 ft. of its upper or lower limit of travel the hoist motor control circuit is automatically opened and the hoist motors stopped. This is provided simply as a safety precaution in guarding against a dead man failure and to make sure that the operator is tending to business. This control circuit can be restored by the operator pressing a button adjacent to the controller.

(7) In seating the bridge it must be brought to within

⅛ of an inch of its proper position before the control circuit for rail lock motors is established.

Rail Locks.

The rail locks consist of heavy steel bars which are moved horizontally by a motor and rack arrangement at each end of the bridge. These locks both hold the bridge solidly in position and at the same time provide a continuous path at the rail head for the cars passing over the bridge. The construction at this point is so well taken care of that there is no jar whatever as the train passes on or off the bridge.

The rail locks are inserted and drawn by a 3¼-h.p. motor at each end of the bridge. These motors are of the crane series type and are geared to a shaft which operates a crank connected to each rail lock. In operating the motors either to draw or insert the rail locks, the bridge operator simply throws the motor starting controller and when the rail locks are either in the closed or drawn position, this fact is indicated by either white or red lights on the controller. It takes about 8 seconds to move the rail locks and the instant they have reached the limit of their travel the motor circuits are automatically cut off and a double braking arrangement causes the armatures to quickly come to rest.

Hoist Motors.

The bridge is raised and lowered by two 325 h. p. series d. c. motors mounted in the machinery house on top of the bridge. They are both of the railway type, equipped with interpoles to provide good commutation. Both motors are directly connected to the same shaft and current passes through the two in series. A large pinion mounted on this shaft engages a train of gears on each side, which connect to the main driving shafts. Upon each end of each large driving shaft is mounted a large steel drum, around which the hoist cables make several turns. The reduction gears and drums are exactly alike so that the bridge is maintained level at all times. The action of the hoist machinery is very similar to that of a spider pulling himself up a single strand web except that the cables are fastened at both top and bottom.

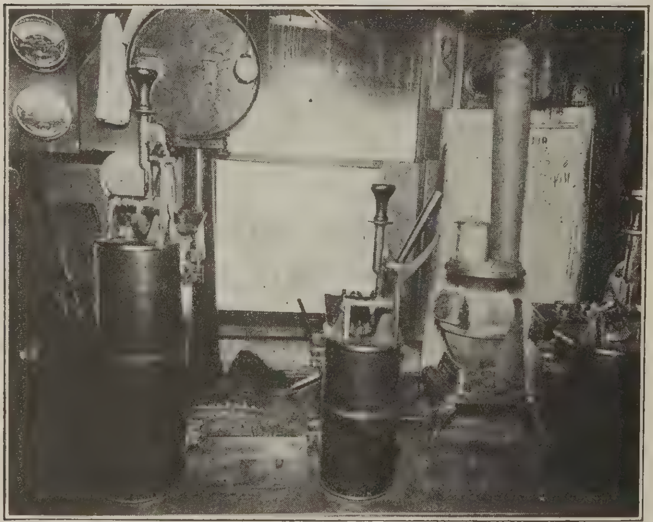


Fig. 6. Operator's Cabin on the Bridge. The Large Dial in the Background Shows the Exact Height of the Bridge in Feet and Inches. On the Left Is Shown the Remote Control for Operating the Hoist Motors, in the Center the Motor Operated Brake Control and on the Right the Remote Control for the Rail Lock Motors.

The accompanying curves, Fig. 10, show the operating characteristics of the motor hoist equipment. It will be noted that the current curve for the up travel is entirely different from that of the downward travel. This shows that the current starts at 1,700 amperes in going up and quickly falls to about 1,000 amperes in the first 20 ft. rise. Then for the next 70 ft. there is a gradual decrease in current required, due to the added weight of the supporting cables on the counterweight side. At a 90 ft. elevation, however, the operator begins to shut off the motors and the current rapidly decreases. In lowering the bridge it is seen that the curve starts at approximately 2,000 amperes, but after moving the first 15 ft. the bridge motion has reached normal velocity and the current required has fallen to approximately 1,400 amperes. This current then steadily declines until the lower limit of travel is reached, this falling off in current, as before, being caused by the weight of the supporting cables being shifted over either to the bridge or the counterweight side of the tower. It will be noted that the current curve on downward motion increases from 850 to 1,300 amperes; this is due to the strong downward pull required to firmly seat the bridge before the rail locks can be thrown. The point at which the current curves for up and down travel cross is obviously the balance point, for it takes just as much power at this position to move the bridge up as it does to move it down. In the curves as shown it is seen that this balance point is found to be when the bridge is elevated 30 feet. The total bridge travel is 110 ft. so the center of bridge travel is approximately 55 feet. high. This shows that the counterweights are theoretically too heavy by an amount equal to the weight of 25 lineal feet of all supporting cables. Since, however, the the majority of the lifts are only partial lifts, it is undoubtedly better practice to have the balance at the lower height, as shown in this curve.

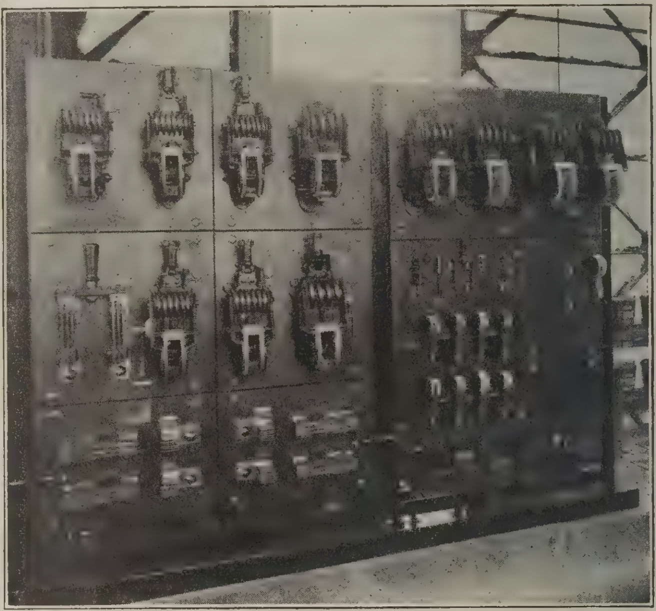


Fig. 7. Switchboard in Machinery House Showing the Automatic Starters and Circuit Breakers Operated from the Remote Controllers in Fig. 6.

The power required to move the bridge at the balance point will then give an indication of the mechanical coefficient of friction of all the bridge machinery. It is noted that the balance point in this curve is at about 950 amperes, which transferred to the curve of cable pull, gives directly a total pull of 90,000 lbs., on all four cables required to simply overcome mechanical friction.

Brake Equipment.

A motor operated friction brake is mounted on the shaft midway between the two motors and just to the left of the gearing, Fig. 8. This is operated by a 5 h. p. series motor, which engages a rack; the motor and its resistance are shown below and in front of the brake. The pressure on the brake is exerted by a spring and the motor operates to oppose the spring pressure and releases the brake. There are three points of adjustment of the motor controller and each position of the controller represents a certain braking power.

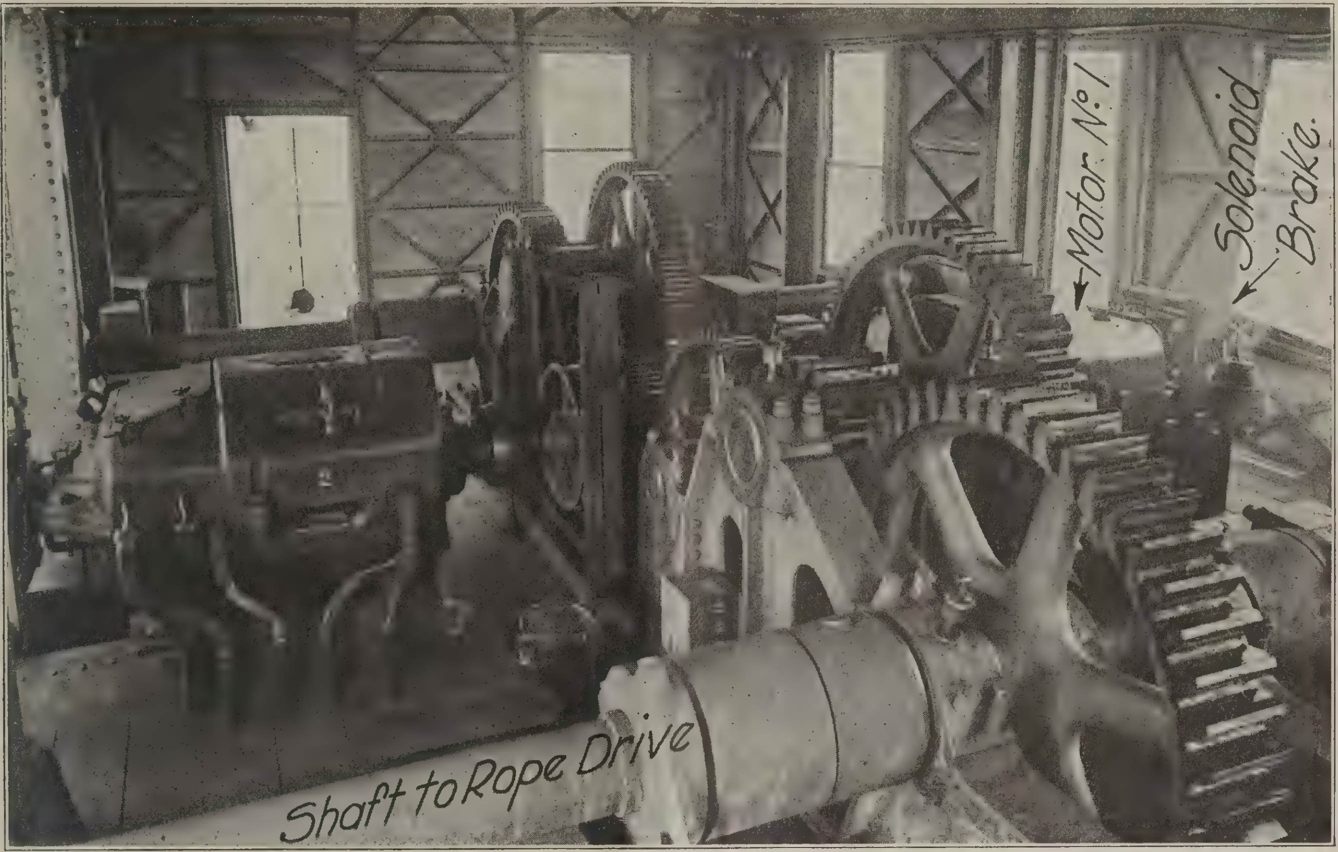


Fig. 8. Machinery House Showing the Motors and Gear Train by which the Bridge Is Hoisted and Lowered. Both Motors Are on the Same Shaft. Motor Operated Brake Is Shown at the Right of Motor No. 2 and Its Operating Motor and Rack Are Shown Below.

A solenoid emergency brake is provided at each motor, as shown in Fig. 9, and as labeled in Fig. 8. The brake pressure is exerted by four springs acting on a toggle lever arrangement and the pull of these springs is opposed and the break released by the magnetic pull of a large solenoid.

These solenoid brakes are ordinarily held in release by a foot lever but can be set in case of emergency. They are not used except in case of emergency, however, as it would throw on full braking power and might strain the operating cables. An emergency hand brake is also provided in the operator's cabin below the machinery house and this is connected by levers to the motor operated brake and the operator can then perform the same work in releasing the brake that the motor does.

Remote Control Panel.

The bridge operator's cabin with controlling levers is located directly below the machinery house but the actual switching and operation of the hoist and rail lock motors is accomplished on the remote control panel mounted in the machinery house above, as shown in Fig. 7. In the lower right hand half of the panel is mounted the automatic controllers for each of the rail lock motors, while directly above are shown four large contactors for reversing connections to the hoist motors. The two double throw switches at the lower left hand corner control each of the motor circuits, while the switch above controls the entire power circuit to the board. At the right of this switch are shown three contractors, each of which short circuits a segment of resistance in series with the hoist motors, while directly above these are three more contactors which perform the same function on additional segments of hoist motor resistance At the upper left hand corner of the board is shown a large contactor which provides for dynamic braking in case of emergency and also when the bridge nears the upper or lower limit of travel.

An overload relay is mounted behind the board to open the hoist motor contactors in case the current be-

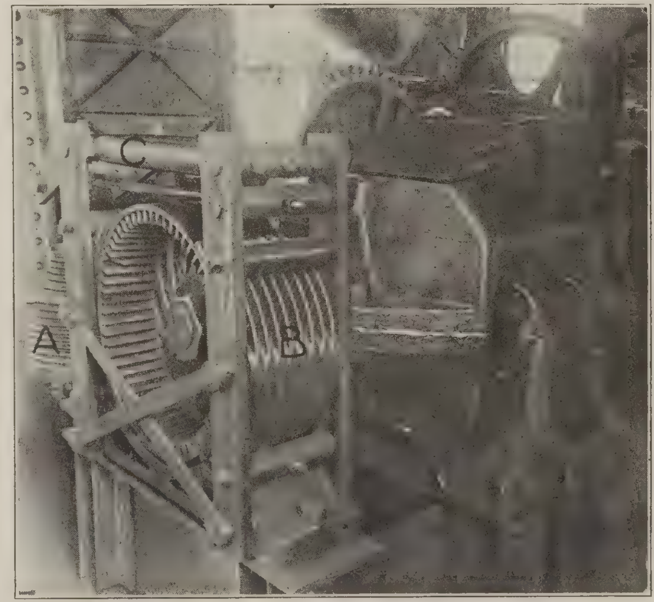


Fig. 9. Emergency Solenoid Brake. All Parts Are Cast With Fins to Aid in Radiating the Heat. Brake Is Set by Springs and Released by Solenoid Every Time the Motors Are Started.

comes excessive. This relay is automatically reset when the operator brings the control lever back to zero. A private telephone line connects between the bridge operator's cabin, the signal tower and the battery house.

Electric Signal Horn.

An electrically operated horn is provided as an audible signal to boat-men on the river. This consists simply of a motor driven knobbed wheel which strikes against a wearing button, mounted on a large metal diaphragm. Two large horns mounted on either side of this diaphragm direct the sound up and down the river.

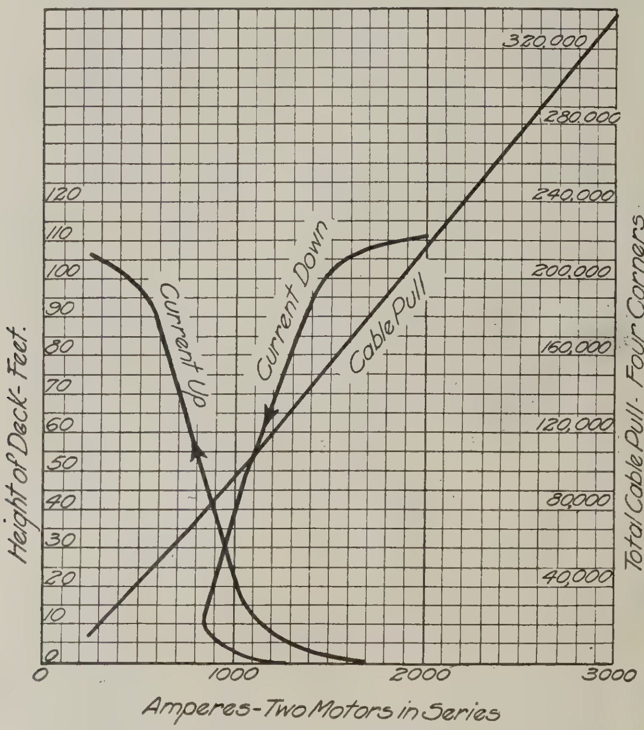


Fig. 10. Curves Showing Variation of Current With Elevation of Bridge.

A large 16-in. electric gong is also provided on the bridge as a warning to employes when the bridge is about to move.

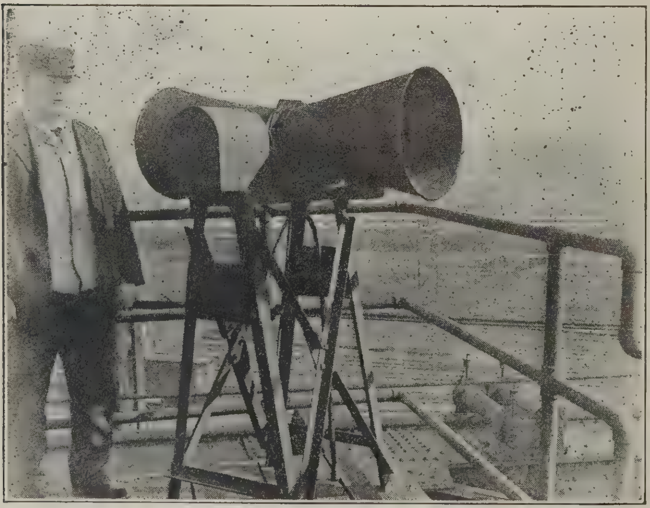


Fig. 11. Motor Driven Knobbed Wheel Horn for Signalling Boats on the River.

Two Bridges Operated by Remote Control.

On the Pennsylvania Lines at South Chicago, there are two similar bridges having identical hoist and control equipment. The control of these bridges, however, is so arranged that the operator on either bridge can lift either one, or both bridges, at will. It will be noted from Fig. 6 that a position has been provided for the rail lock, brake and hoist controllers of a second bridge, which may be installed at some future date and by having duplicate control equipment on both bridges, either one, or both bridges, may be operated from either bridge.

We are indebted for the information given in this article to Mr. C. J. Causland, Chief Elec., Pennsylvania Lines West, and to Mr. R. M. Gaston, of the George P. Nichols Co., who designed all details and had charge of the installation of electrical equipment on the bridge. The control board was manufactured by the Cutler Hammer Mfg. Co.

G. E. Exhibit at Panama Fair

The exhibit of the General Electric Company in the Transportation Building at the Panama-Pacific International Exposition will be very extensive and will comprise electric locomotives for various classes of service, including steam railroad electrification, railway motors and all kinds of apparatus and accessories for electric railways, signal accessory electric devices, electric apparatus and equipment for railway shops, electric illumination for cars and shops, etc.

Electric Locomotives Which Are Now on Exhibit at the Panama Exposition, Coupled Together for Transportation.

One very interesting exhibit will be the electric locomotives shown in the illustration coupled together ready for shipment across the continent. The Butte, Anaconda & Pacific locomotive is one of four units which have recently been built for this road and is a duplicate of the original seventeen units put into service in 1913.

A 60-ton electric locomotive of the type built for interurban freight and passenger service will be on exhibit. This machine is designed for both 600 and 1200-volt operation. The cab is of all-steel construction and is divided into three sections, the central operating cab containing the controller and other apparatus that should be within immediate reach of the engineer, and the two end steeple back cabs containing the auxiliary electrical apparatus.

There will also be a 16-ton electric locomotive of similar design with steeple-back end cabs for industrial freight and switching service. It is equipped with two commutating pole ventilated motors. Two types of mining electric locomotives will be shown.

In another rack the operation of the multiple control as applied to cars for three-speed operation in city service will be demonstrated. An exploded 600-volt motor will be exhibited to show the motor construction.

A stereomotograph will show important applications of recent railway equipment in city, interurban and heavy electrification service.

Three-Phase Italian Passenger Locomotives

The Società Italiana Westinghouse is now delivering to the Italian State Railway sixteen three-phase locomotives. These new machines have two 3,300-volt, 16.7-cycle induction motors of 1,300 hp. each, of the slip-ring type. The stator windings are designed so that the coils can be grouped either for two-phase, six poles, or three-phase eight poles. Similarly the rotor has a special winding which can be connected for either two-phase, six poles, or three-phase, eight poles. Only seven slip rings are required. A group of three or a group of four of the seven slip rings can be connected to the stator of the second motor when a three-phase, eight pole, or two-phase six pole cascade is required. Otherwise they can be short-circuited through the water rheostat when the motors are connected in parallel to the line. The two motors, of course, are connected mechanically.

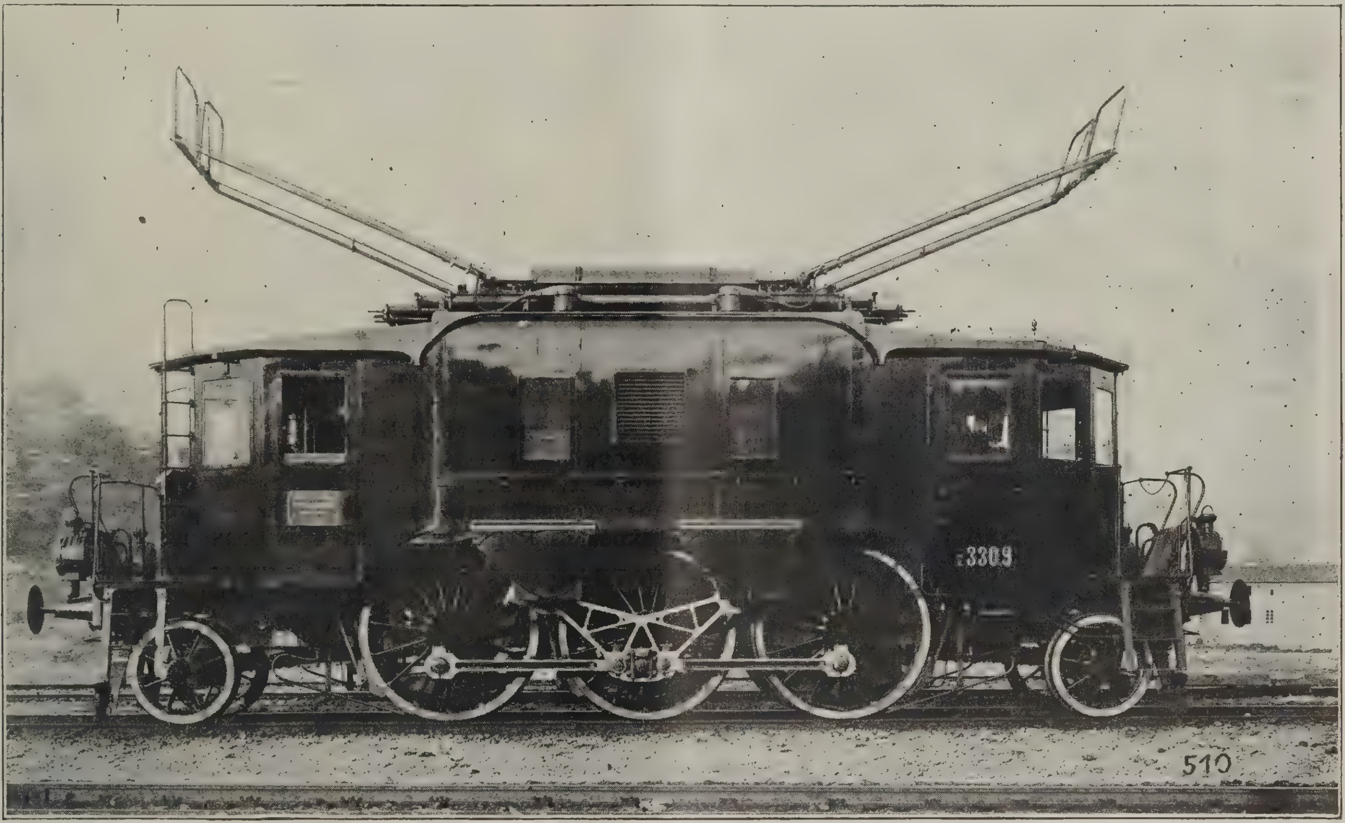


Fig. 1. High Speed Passenger Locomotive, Built by Società Italiana Westinghouse, Operating Three-Phase and Having a Capacity of 2600 h.p. Speed Range from 23 to 65 m.p.h.

Four Efficient Speeds.

By connecting the motors in parallel on the line (connected either for two-phase, six poles, or three-phase, eight poles), or connecting them in cascade, a four-speed combination can be obtained which at 16.7 cycles with a wheel diameter of 1.63 m. (64.2 in.), gives four running speeds of 23.3, 31, 46.6 and 62 m.p.h. These are fully sufficient for passenger service locomotives, not only on level lines, but also on fairly high grades.

The change of the motor connections from parallel to cascade and also from six to eight poles, two or three-phase, is made by a drum type controller operated through electropneumatic relays by a master controller. The method of starting the wound-rotor induction motor is by means of a liquid rheostat with an automatic regulation feature which increases or decreases automatically the amount of resistance inserted in the rotor, so as to keep the power absorbed from the line fixed at a predetermined value. It is also supplied with a motor driven centrifugal pump which is inserted in the line as soon as the rheostat is in operation. This pump throws a jet of water against the resistance plates to prevent concentration of heat at the surface of the water, so all the water assumes an even temperature.

Automatic Regulator.

The automatic regulator is designed so as to regulate for constant watts instead of constant current, as was the case in the older type of rheostat. The regulator consists of a laminated core with a two-pole winding connected in series on the ground phase of the motor and constituting the stator, and of double T-shaped rotor with a winding inserted between the other two rotors winding inserted between the other two phases. The torque exerted between stator and rotor is counterbalanced by a spring, and the tension of this spring can be regulated by the starting controller operated by the motorman so as to predetermine the amount of power to be absorbed from the line by the motors. When the power absorbed by the motor exceeds a predetermined value, the regulator tends to rotate in one direction, thereby increasing the resistance inserted in the rotor which in its turn decreases the power absorbed; vice versa, when the power absorbed tends to decrease, the regulator rotates in the other direction, thus keeping the amount of power taken by the motor at a constant value. Besides the controller and liquid rheostat, the locomotive is equipped with the usual auxiliary apparatus and instruments. There is, however, in additon, a small transformer to change the power supply from three to two-phase.

Wiring Diagram.

Fig. 7 shows the connection between the overhead line and the primary switch through the trolley, impedance coils, and oil switch; also the circuit supplying the auxiliary apparatus with fuses, lightning arresters, and transformers. The three phases consist of two overhead wires and the rails or ground phase. There are, as already mentioned, four connections of windings and motors to obtain the four running speeds.

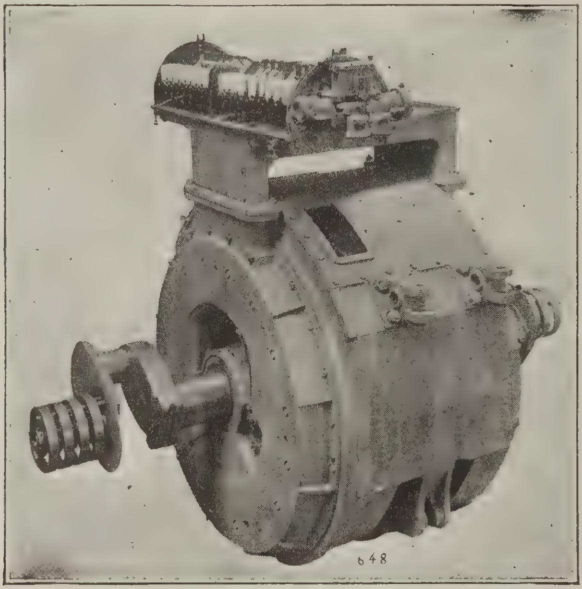


Fig. 2. 1300 h.p. Three-Phase, 3300 Volt Motor for Passenger Locomotive.

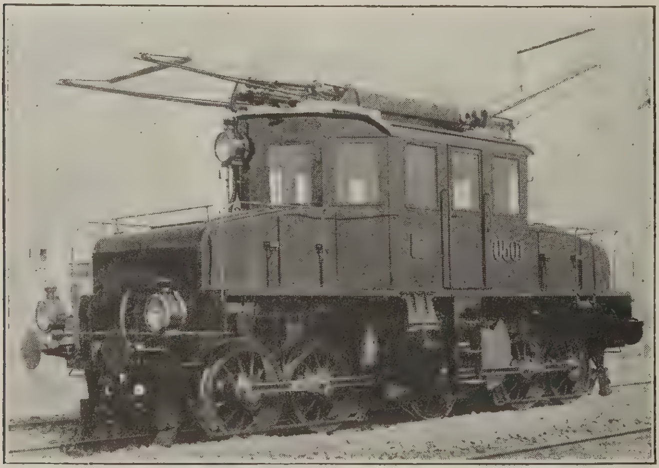


Fig. 3. 2000 h.p. Three-Phase Freight Locomotive.

Two connections are shown in Fig. 6; that is, the three-phase eight-pole cascade and the two-phase six-pole parallel. All of these connections are made by the controllers, which are never operated under load. The connections from the slip rings to the water rheostat are shown in Fig. 8. The water level, rising in the rheostat, fills the space between the plates, thus short-circuiting the rotor windings, which are connected to the plates as shown. The controller, the trolley and the liquid rheostat are operated by compressed air supplied by a small three-phase motor and compressor, which also supplies the air for the two air brakes (the automatic and straight air brakes).

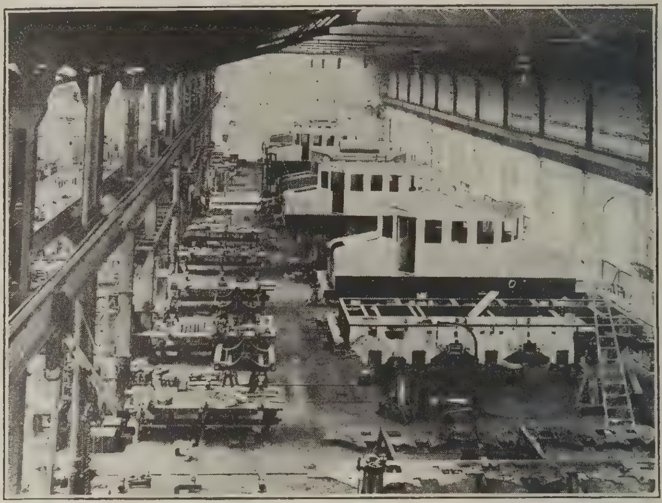


Fig. 4. Shops of the Società Italiana Westinghouse, Railway Department, Vado Ligure, Italy.

The motors are well ventilated with air circulation through the stator iron and winding. The stator end connections are dipped in an insulating compound and then covered with a brass plate to prevent damage. Experience has shown that this construction has done away with insulation break-downs due to moisture and vibration caused by heavy currents at starting.

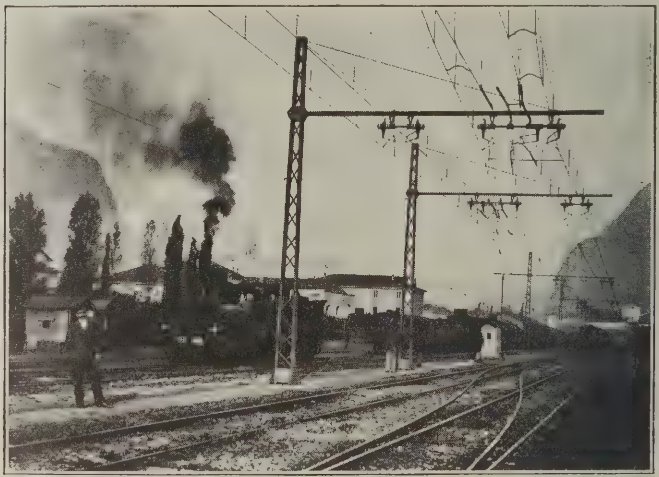


Fig. 5. Westinghouse Overhead Line Construction of Three-Phase, 3300 Volt, on the Lecco Çalozio Line.

The Locomotive.

This locomotive has five axles, and is of the 2-6-2 type, that is to say, two axles are supporting axles and the other three are driving. The two supporting axles are placed one at each end of the locomotive, and each is connected to the driving axle next to it so as to form a kind of truck. All three driving axles have a transverse play for easy operation on curves. The slip rings are outside the wheelbase and easily accessible.

The weight of the locomotive, complete is metric 73 tons of which 45 to 51 tons is adhesive weight. The weight on the drivers can be changed within these figures by an arrangement which shifts the weight from the drivers to the supporting axles. The weight and dimensions of the locomotive are given in Table 1.

Table I—Weights and Dimensions.

Mechanical equipment	30,650 kg.	67,500 lb.
Items	Weights	
Motor equipment	27,270 kg.	60,000 lb.
Mechanical equipment	30,650 kg.	67,500 lb.
Control equipment	12,700 kg.	28,000 lb.
Air-brake equipment	2,300 kg.	5,050 lb.

Items	Dimensions	
Maximum width	3.05 m.	120 in.
Maximum length	11.00 m.	434 in.
Diameter of driving wheels	1.63 m.	64 in.
Diameter of poney truck wheels	0.93 m.	37.8 in.

The motors are mounted on the frame in such a way that the air gap of the motor can be kept as small as electrical considerations will permit. This is done by making the bearings which support the rotor rigid with the stator frame, and independent of those which support the revolving shaft. The locomotives are designed for the Giovi subsidiary line and for the Monza-Lecco line, which connects Milan to the Lake of Como and the Valtellina lines which were electrified in 1901 with the same system. The Monza line is level single-track, while the Giovi subsidiary is double-track and has fairly high grades, reaching 1.6 per cent in the open and 1.16 in a 5.2-mile tunnel.

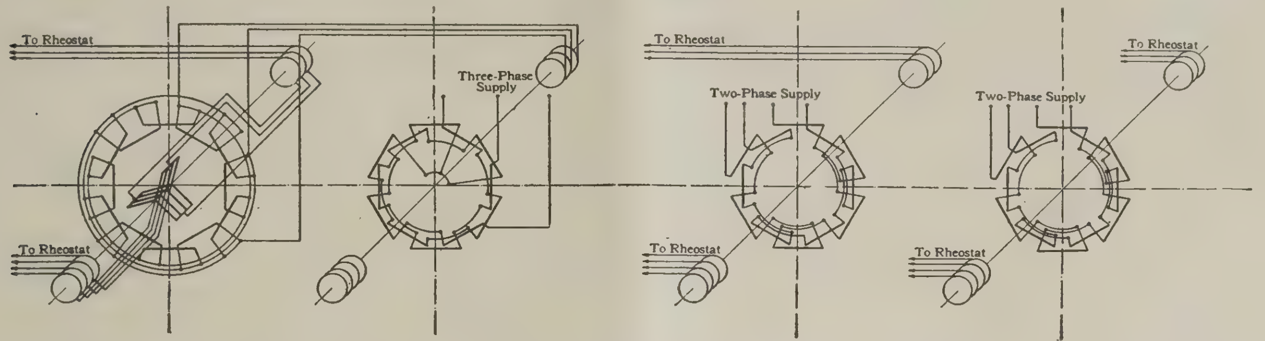


Fig. 6. Typical Motor Connections on Italian Passenger Locomotives Showing Method of Connecting the Two Motors for Three-Phase, Eight-Pole Cascade (Left) and for Two-Phase, Six-Pole Parallel (Right).

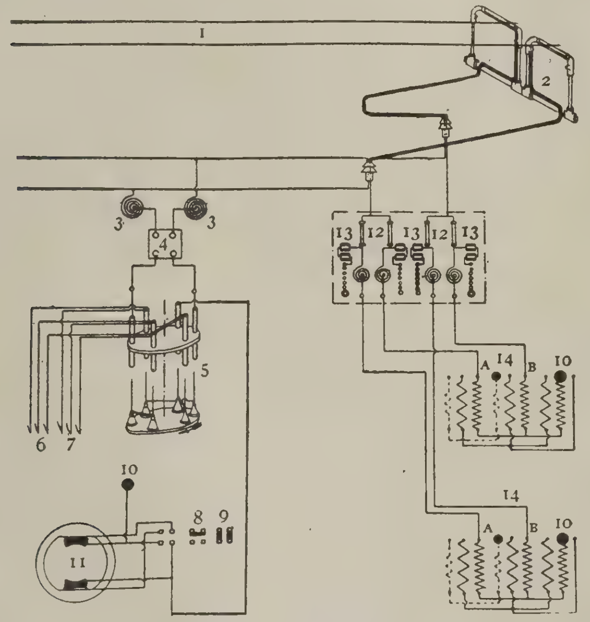


Fig. 7. Wiring Diagram Showing Connections From the Trolley to the Motor Switch. 1, Contact Wires; 2, Trolley; 3, Inductance Coils; 4, Automatic Circuit Breakers; 5, Primary Switch; 6 and 7, to Motor Primaries; 8 and 9, Connections of Automatic Regulator for Cascade and Parallel Connection, Respectively; 10, Ground Connections; 11, Stationary Part of Automatic Regulator; 12, Fuses; 13, Lightning Arresters; 14, Transformers with Primary A and B, Respectively.

Operating Results.

Some figures regarding the performance and tests of this type of locomotive may be interesting. The normal rating of the two motors is 2,600 h.p. at three-phase, 16 2-3 cycles, 3,300 volts and is such that the locomotive can develop for one hour continuously the drawbar pulls given in Table II with a motor temperature rise not exceeding 75 deg. Cent.

Table II—Relations Between Drawbar Pull and Speed.

Drawbar Pull		Speed	
9,000 kgm.	19,800 lbs.	37.5 km.p.h.	23.3 m.p.h.
9,000 kgm.	19,800 lbs.	50 km.p.h.	31 m.p.h.
9,500 kgm.	20,900 lbs.	75 km.p.h.	46.6 m.p.h.
6,000 kgm.	13,200 lbs.	100 km.p.h.	62 m.p.h.

This locomotive can start a train of 350 tons (exclusive of locomotive) and bring it up to 75 kw. p.h. (46.6 m.p.h.) speed on a straight line having a grade of 1.2 per cent with acceleration of 0.15 km. (0.093 mile) per hour per second; the tractive effort at starting is such as to utilize fully the adhesion between zero and 75 km. (46.6 miles) per hour speed.

Of these locomotives the Italiana Westinghouse Company has already built sixteen and their operation is very satisfactory. They are run regenerating on the down grades, in this way greatly reducing the operating expenses. Their cost compares favorably with the cost of electric locomotives in the United States; however, the ratio of horse power to weight, or 2,600:73, is considerably higher.

These locomotives are rapidly solving the problems of high speed freight and passenger service on the lines on which they have been installed. Some doubts were expressed some time ago as regards the overhead line having two wires. However, no trouble has been experienced, although the overhead construction, with sliding pantograph construction would be considered rather light in this country for such service.

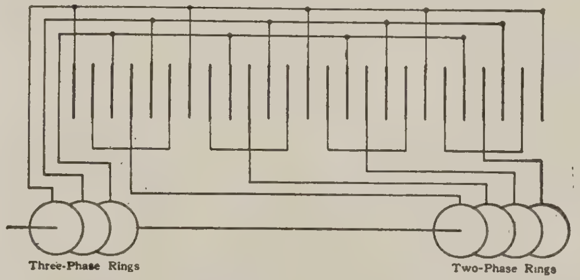


Fig. 8. Liquid Rheostat Connection From Motor Slip Rings.

Electrification of East Prussia Proposed.

Count Mirbach-Sorquitten has submitted a comprehensive proposal to the Prussian Ministry and the chief of the Province of East Prussia, suggesting the assignment out of state funds of a considerable endowment for the electrification of that province, which is said to have been severely damaged by the war. As the basis for the proposal the Count points out the dearth of labor and the scarcity of horses, which offer insurmountable difficulties in the way of the revival of economic activity. It is held that the only remedy is to proceed with the establishment of great power works.

The Railroad Electricians' Club

Meetings the 3rd Monday of Every Month, 8 P. M.—18th Floor Transportation Bldg., Harrison and Dearborn Sts., Chicago—Everybody Welcome—No Dues

Constant Potential Charging and the E. S. B. System

By J. Lester Woodbridge

At the February meeting of the club in Chicago Mr. J. Lester Woodbridge, chief engineer of the Electric Storage Battery Company, gave an informal talk on the subject on "Constant Potential Storage Battery Charging and the E. S. B. Axle System." Mr. Woodbridge showed numerous lantern slides which illustrated the operation of the system and described the principles of operation of constant potential charging in considerable detail. The former, however, has been covered by us in our Lesson No. 22, November, 1913, so we will omit much of this portion of the talk.

He pointed out the fundamental characteristics of the machine, showing that it operates on a constant potential principle instead of constant current or combination current and voltage as in other types and that this potential is maintained constant regardless of rise in train speed above a certain value and also regardless of the condition of battery charge, except in case of an exhausted battery. By referring to the wiring diagram herewith, the operation of the equipment can be followed.

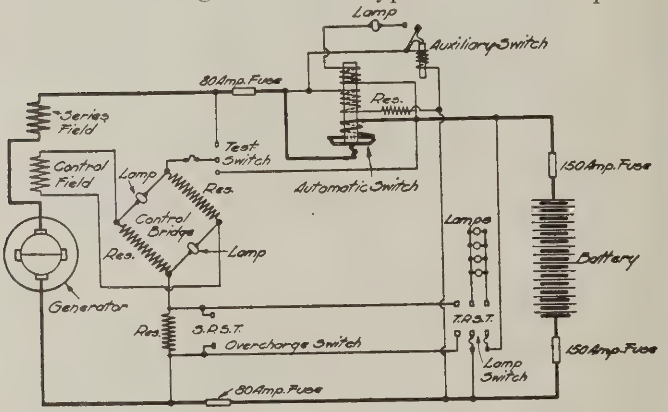


Fig. 1. Diagram of E. S. B. Generator and Regulator.

The E. S. B. Generator.

It will be noted that the generator is radically different from all other types in that the brushes midway between the two pole shoes are directly short circuited. A slight voltage generated across these brushes will cause a fairly heavy short circuiting current to circulate through the armature coils and this current will generate a magnetic field in the armature perpendicular to the primary field and deliver full battery voltage at the brushes directly under the center of the pole shoes. He pointed out that this short circuiting current simply makes a big field magnet out of the armature. A weak primary or control field perpendicular to this is, of course, maintained by current flowing through the primary field circuit. On higher speeds this primary field current is gradually reduced as the voltage tends to rise above normal by the action of the Wheatstone bridge.

It will be noted that the primary control field is connected across the middle of the bridge. Two banks of iron wire ballast lamps at opposite corners of the bridge, permit a heavy field current to flow when the voltage is low, but when the voltage rises to normal value the current through the two resistances making up the other sides of the bridge, becomes nearly equal to the current through the ballast lamps and the potential across the middle of the bridge where the control field is connected, falls to a low value. In fact at a certain speed the field magnets will fall to zero and on the higher speeds there will actually be a slight reverse current through the control field opposing the residual magnetism of the generator.

He pointed out that although the generator delivers constant potential its characteristics are such that on a very heavy overload, such as would be experienced when the battery had been complete discharged, the voltage of the generator will be automatically reduced, due to magnetic leakage from the pole shoes to the frame and the current output will be kept within the limits of the generator capacity. Therefore the generator can be short circuited without injury.

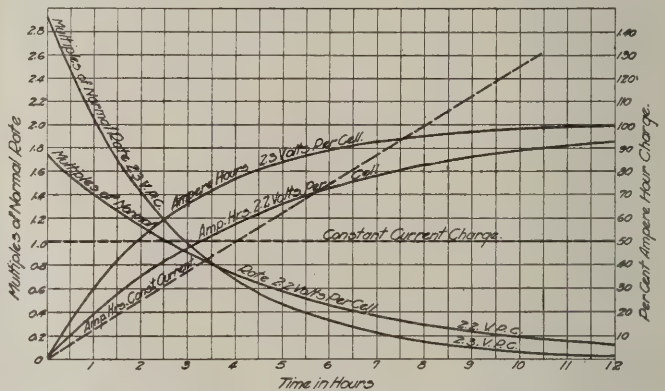


Fig. 2. Curves Showing the Tapering in Charging Current and Ampere Hour Charge at 2.2 Volts and 2.3 Volts per Cell.

If it is thought necessary, the charging voltage can be increased so as to give the battery a strong overcharge by opening the overcharge switch. He pointed out that even though the control field circuit should open, there would be no failure of the equipment for at a speed of 25 miles per hour the residual magnetism of the generator would be sufficient to deliver full voltage. Moreover, even though the battery polarity should be reversed through wrong connection, the machine would build up as usual closing the automatic switch ,whereupon the opposite polarity of the battery applied to the whetstone bridge would actually reverse the generator, bringing the voltage back through zero, opening the automatic switch and the generator would then build up in the opposite direction, presenting proper polarity and again closing the automatic switch, whereupon the equipment would operate satisfactorily.

Test Switch.

He called attention to the test switch by means of which the control bridge can be connected directly to the battery circuit. In doing so all circuits of the control bridge are tested and at the same time a heavy current in the right direction is sent through the control field, which greatly strengthens the residual magnetism of the machine and insures that the generator will build up positively and in the right direction.

Automatic Switch.

Mr. Woodbridge then pointed out that the automatic switch of this system is entirely different from any other in that it operates on a difference in voltage between battery and generator rather than at a certain definite generator voltage. The switch consists of (1) the usual series coil for strengthening the switch pull. (2) A main shunt coil which is not strong enough to lift the switch alone or even keep it closed without assistance from the series coil or the auxiliary coil, and (3) An auxiliary coil wound for low voltage operation and connected between battery positive and generator positive. The circuit of the auxiliary coil is closed by a relay when the generator voltage gets above a certain value and until the generator voltage equals the battery voltage the magnetism of this auxiliary coil will oppose the main coil, but when the generator voltage rises a fraction of a volt above the battery voltage, a reverse current through the auxiliary coil will assist the main coil magnetism and close the switch positively. Even a two pound weight hung on the plunger of the automatic switch will have no appreciable effect on its operation.

In stopping, the automatic switch it falls open at practically zero current, for when the generator voltage falls to that of the battery there will be no current through the series coil and no current through the auxiliary coil, and since the main coil is not sufficient to hold the switch closed alone, it will drop open with no sparking at the switch contacts. Therefore no carbon break contacts are provided.

Constant Potential Charging

Mr. Woodbridge showed a characteristic diagram of constant potential charging as per Fig. 2 and pointed out that with a constant potential at the battery terminals of 2.3 volts per cell and a certain resistance due to leads and inter-cell connections in the battery circuit, the charge will start at about three times normal, and at the end of one hour drop to twice normal, and at the end of three hours will drop to normal as shown in Fig. 2. If the voltage is maintained constant at 2.3 volts per cell the charging current will continue to taper off until after 7 hours it will be only about ¼ normal rate and after 9 hours, 1/10 normal rate. He pointed out that in charging on this basis the battery capacity will be much more quickly refilled at the beginning of charge than when it is charged on constant current basis. Moreover, he stated that the battery seems to be in no way injured by heavy charging current at the beginning of charge so long as the cells do not gas or become overheated.

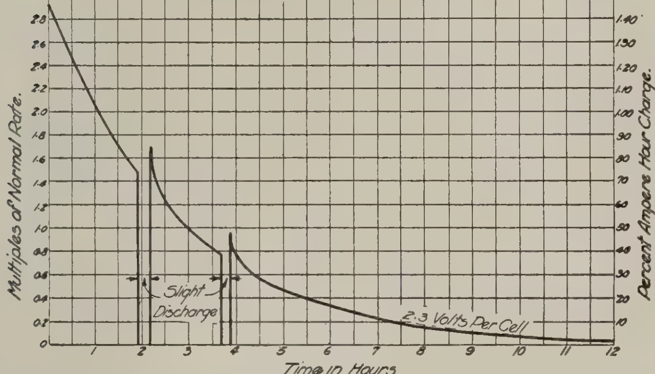


Fig. 3. Curves Showing the Effect of Intermittent Charging at Constant Voltage, Upon Resuming Charge the Rate Is Temporarily Increased. (Curve by the Editor.)

With a lower charging voltage of 2.2 volts per cell, the charging rate starts at a lower value but holds up higher after several hours charging than on the higher potential. At this voltage the rate of restoring the battery charge is, of course, considerably reduced, but if the charge is continued long enough the cell will be brought up to full capacity and the charging current tapered to practically zero.

He stated that where a battery is charged at constant current much of the current is wasted at the end of charge due to gasing the battery. The charging current flowing through the battery can do only one thing; if it forms gas it cannot perform useful service in reducing the sulphate of the plates.

Mr. Woodbridge stated that a rule had been worked out from the constant potential charging curves as follows: At a charging voltage of 2.3 volts per cell it is found thot the charging rate in amperes corresponds approximately to the number of ampere hours *out* of the battery. This rule can be followed by manually reducing the charging current in order to produce a taper charge where no constant potential is available. This will just kep under the gasing point of the battery at all times during the charge.

If the charge is stopped at any time and the battery left on open circuit or discharged for a few minutes and then connected again to the constant potential charging source the current will start a much higher value than before the circuit was opened, but it will quickly taper down to this value as shown in the accompanying diagram, Fig. 3.

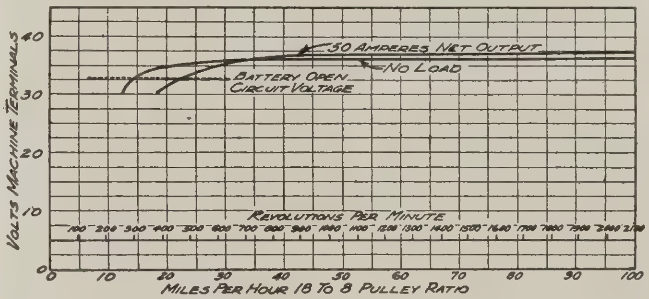


Fig. 4. Characteristic Curve of Generator Showing the Voltage at No Load and Full Load at Various Speeds.

Test Data.

Mr. Woodbridge then presented service data on the operation of the E. S. B. system, as given in the accompanying table, which shows how admirably the constant potential system adjusts itself to different conditions of operation.

Record from Chicago to Pacific Coast with no Change in Adjustment.

	Ampere Hours	
	Chair Car	Diner
Generator	930	2787
Battery charge	303	397
Battery discharge	236	321
Battery overcharge	67	76

It will be noted that the E. S. B. equipment has no lamp regulator whatever. In discussing this point Mr. Woodbridge stated that the average lamp life on a number of cars was found to be 1,500 hours, this was determined from the indication of an ampere hour meter in the lamp circuit.

Questions

Sulphated Plates.

Mr. J. M. Lorenz asked how a battery that was in a badly sulphated condition could have the sulphate in its plates reduced by charging at such a low voltage as 2.3 volts per cell.

Mr. Woodbridge stated that where sulphated plates are connected to a high voltage source much of the current is consumed in gasing and that gasing plays no part in actually reducing the sulphate. He stated that badly sulphated plates are reduced just as quickly when charged at a low voltage and a low rate as when they are charged at a high voltage and a high rate.

Commutation.

Mr. Wray pointed out that in the design of all direct current generators the brushes are always placed so as to commutate in the neutral plane where the magnetic flux is zero. Since this machine is a two pole machine we would expect to find only two neutral points, and since there are four brushes placed at the quarter points on the commutator, we would expect that two of these brushes would commutate at off-neutral points where the armature coils, when commutated, would be generating some voltage which would produce sparking under the brushes.

Mr. Woodbridge stated that although this is a two pole machine there are actually four neutral magnetic points, for the magnetism falls off to zero midway between each of the pole tips and also under the notches at the center of the pole shoes, so that at the instant the coils pass under the brushes they are generating practically no voltage whatever and there is no sparking.

Ampere Hour Meter Control.

Mr. Oberly, of the Pullman Company, stated that a large number of Pullman equipments are now operated with ampere hour meter control of charge and after the meter cuts off charge the battery floats at from 34 to 35 volts. Although this does not give the same charging curve as the taper charge, the beneficial results of protection from overcharge and a soaking charge at the end of taper are obtained. He stated that considerable difficulty had been experienced this winter in preventing belts from slipping, due to a light dusty snow being blown under the belt. They had tried nobby tread pulleys and aluminum pulleys and stated the aluminum pulleys seemed to give a much better friction than the other types.

A vote of thanks was then extended to Mr. Woodbridge for his excellent talk.

In the business meeting of the club it was decided to appoint a committee on reorganization, as follows:

C. J. Causland, Penn. R. R., Chairman.
C. C. Oberly, Pullman Co.
George B. Colegrove, Illinois Central Ry.
Edward Wray, Railway Electrical Engineer.

Lead Storage Battery Questions

Reserve Lead.

Q. 94. What is meant by reserve lead in a plate?

Ans. 94. Reserve lead in plante type plates is the uniformed metallic lead deep down in the ribs and fins of the plate. This reserve lead is gradually formed into active material during the life of the plate and where the battery is treated properly the formation of new active material from the reserve lead should take place about at the same rate as the active material on the face of the plate is worn away and falls to the bottom of the tank.

Holes in Rubber Separators.

Q. 95. Why do the rubber separators have holes?

Ans. 5. Current must flow through the electrolyte in passing from one plate to the other. Since rubber is a good insulator it would tend to insulate the one plate from the other and prevent the flow of current through the electrolyte if there were no holes in the separators. Of course the larger and the greater number of these holes, the lower will be the resistance of the current path, but at the same time the manufacturer must make these holes reasonably small and well separated to prevent a metallic short circuit between plates, due to the formation of lead trees, etc.

The Vent Plug.

Q. 96. What is the vent plug in the battery cover for?

Ans. 96. A certain amount of gas is given off by a battery in normal operation and at very high rates or on overcharging this becomes excessive. This gas, as explained before, consists of hydrogen and oxygen, the constituents of water, which has been decomposed by the electro chemical action of the current flowing through the battery. If some provision were not made whereby these gases could easily escape they would soon be liberated in such quantities as to generate sufficient pressure to burst the cell.

How Lead Batteries Are Made

Difference Between Pasted and Plante Plates.

Q.—97. What is the main difference between the manufacture of pasted plates and plante type plates?

Ans. 97. Pasted plates are made by filling a lead antimony cast grid with a paste made of red litharge (a superoxide of lead), which is held together with some binding material. The plates are then dried and given a few charges and discharges to convert the red lead paste into lead peroxide and sponge lead in the positive and negative plates respectively. The antimony lead alloys used in making the grids of the pasted type plates resists the forming action of the current much more than pure lead does and, at the same time, is much harder and stronger. Therefore, there is no gradual formation of active material in pasted plates in service, as there is in the plante type plates. The battery capacity is maximum when new and gradually decreases throughout its life.

The plante type plate is made entirely of pure soft rolled lead. The surface of this sheet of lead is worked up into a great many thin fins or leaves, all of which attach to a central rib. This gives the plate probably ten times the surface that it ordinarily would have and greatly increases the possibility of acid action.

The active material of these plates is formed by charging them as positives in some strong oxidizing or forming agent, which eats into the metallic lead to a slight depth over the entire surface of the plate and converts the metallic lead into lead peroxide. The longer that this forming action is carried on, the greater depth will the lead be formed into active material, and hence the greater capacity will the battery have.

After the plates have been properly formed they are removed from the forming agent and thoroughly washed so as to remove all trace of the forming agent, for if any of this is left as an impurity in the cell when put into operation, it will continue forming the reserve lead at an excessive rate.

Negative plates are formed in exactly the same manner as the positives and the active material is formed as lead peroxide, but this is afterward reduced to sponge lead by connecting the plates up as negatives either with lead dummies or with positive plates and the combination is then charged for several hours. The peroxide which was originally formed in these negative plates is then soon reduced to lead sponge.

Type of Plate Most Used for Car Lighting.

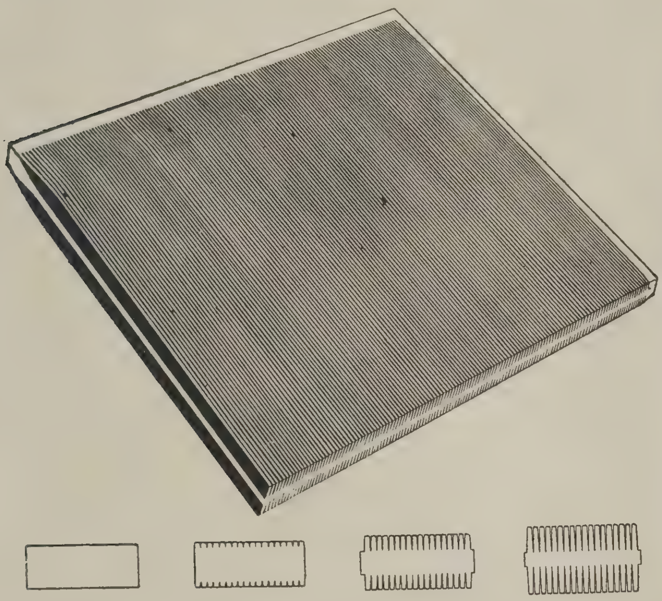
Q.—98. Which type of plate has been used most in railroad service, and why?

Ans. 98. The plante type plate has been more extensively used in car lighting than the pasted type plate, and this is doubtless due to the fact that it is able to withstand better than the pasted type, the overcharging conditions which have prevailed in car lighting service up to recently. With the present refinements for controlling the battery charge, either on an ampere hour basis or a constant potential or combination current-voltage basis, as are now in general use, however, the pasted type plates should give much more satisfactory service than they did in former years and no doubt the next few years will see a more extensive use of the pasted type of plate in car lighting service.

Manufacture of the Gould Plante Plate.

Q.—99. How is the Gould plante type plate made?

Ans. 99. In the Gould spinning process, the rolled lead blanks are placed in a steel frame which reciprocates back and forth between two revolving mandrils on which thin circular steel discs and spacing washers are mounted. The thickness and form of the revolving discs determines the width and shape of the groove between the ribs, and the thickness of the washers, the thickness of the ribs. Enough unspun material is left at the edges and in the center of the plate to form a substantial support and conducting frame. As the blank moves back and forth between the spinning rolls a uniform pressure of the revolving discs is maintained against the surface of the lead blank by means of compressed air. Ridges and grooves begin to appear as soon as the operation is started and as the spinning discs sink further and further into the lead, the lead blank is slowly formed into thin ribs which fill the space between the revolving discs. No lead is removed, the blank is merely changed in form, the active material is then formed on this blank plate, as explained in Problem 97.



Showing Method of Manufacture of Gould Plate.

Manufacture of the Willard Plate.

Q.—100. How is the Willard plante type plate made?

Ans. 100. The surface of the lead blank of the Willard plante type plate is raised into thin ribs or laminations by means of a rigid tool placed in a special machine made for this purpose. These ribs are made one at a time and by shaping the tool properly they can be given any form and thickness desired. In positive plates the ribs taper from the base at the center of the plate, gradually getting thinner toward the outside of the plate. This plate is provided with a center web which is 1/16 of an inch at the bottom of the plate and which tapers to a rather thick section at the top. This is to provide an even distribution of current over the top and bottom of the plate. The entire surface of the plate is developed, no ribs being left at the edges, since the center web is considered strong enough for mechanical support and heavy enough for electrical conductivity.

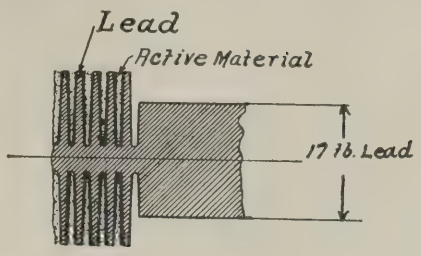


Diagram of Positive Plate

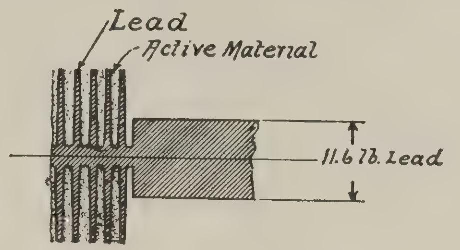


Diagram of Negative Plate

Willard Plate in Process of Manufacture.

It will be noted from the diagram that there is a considerable difference between the form of the positive and negative plate, the negative having much less reserve lead than the positive; this is done because the formation at the negative is very slight. The active material is formed after the lead plates have been worked into shape in the usual way by means of a forming agent.

Manufacture of the U. S. L. Plante Plate.

Q.—101. How is the U.S.L. plante type plate made?

Ans. 101. In the U. S. L. system of making plates the leaves or ribs of the plate are formed by the rocking action of sets of knives which slowly force their way into the body of the blank plate and gradually work it up into the many leaves required to give the plate proper surface. These leaves are formed entirely by displacement of the lead, no material whatsoever being cut away. The leaves of the positive plate are continuous from top to bottom. The negative plates, however, are of the four biscuit type with a horizontal and vertical rib running through the center of the plates. The active material is formed in the plates in the usual manner with a forming agent.

Formation of Active Material.

Q.—102. How is active material formed in between the ribs of these plates?

Ans. 102. After the surface of these plates has been worked up into leaves or thin laminations they are placed into a strong forming agent bath and charged for a long period of time as positives. This forming agent is of a strongly oxidizing nature and, combined with the electro chemical action at the positive plate where nascent oxygen is liberated, strongly attacks the surface of the lead plate and forms it into lead peroxide. This action is continued until the lead is oxidized to a sufficient depth to give the battery its rated capacity.

The peroxide formed from reserved lead occupies considerably larger volume than did the metallic lead, and since this oxidizing action goes on over the entire surface of the lead ribs, the peroxide formed will soon fill the space between the lead laminations of the plate.

Formation of Negatives.

Q.—103. What is the difference between forming a positive and forming a negative?

Ans. 103. As mentioned before, the negatives are originally formed as positives, the active material being lead peroxide. After this has been formed to a proper depth in the plates they are removed from the forming agent, very carefully washed to remove all trace of the forming agent, and placed in fresh electrolyte and charged as negatives. The electro chemical action of the charging current first reduces the peroxide to lead oxide (or more correctly lead sulphate PbsO4) and as the charge is continued further this is still further reduced to sponge lead (Pb) which is the active material of the negative plate.

Reason for Taper of Lead Ribs.

Q.—104. Why are the ribs made so that they taper from base to tip, being thick at the base deep down in the plate and thin at the outer edge of the rib at the surface of the plate?

Ans. 104. By having the lead ribs taper from the base to the tip they are both mechanically stronger, provide a more uniform distribution of current over the body of the active material and seem to give the plate a longer life, due to the greater thickness of the ribs deep down in the plate. It is a well known principle in figuring sizes of electrical conductors that the heavier the current, the heavier must be the conductor. The metal at the base of the rib must carry the current not only for the active material on the surface of the base of the rib, but also to the active material at the tip of the rib. Therefore the metal section at the base should be heavier than at the tip.

As the negative material is gradually formed in service the reserve lead at the thin edge of the tip will soon be completely formed into active material, but there will be sufficient reserve lead in the thicker section of the rib at the base to both give the plate mechanical strength and electrical conductivity. If the ribs were of a uniform thickness the formation would go on uniformly over the entire surface and the base would be so weakened as to probably allow the entire rib with its active material to be mechanically broken off with the vibration and swelling in service.

Reserve Lead.

Q.—105. Why isn't all of the lead in the ribs converted into active material? This would give the plate a much higher capacity.

Ans. 105. It is true that if a larger amount of the reserve lead of the plate is converted into active material by the manufacture in this forming process, it will give the plate a much higher capacity. This, however, will use up more of the reserve lead in the ribs of the plate so when the battery is placed in service and the normal formation continued, this reserve lead which has been already nearly exhausted in making the plate of high capacity, will soon be completely used up, and a plate without reserve lead for conductivity and mechanical strength will very quickly go to pieces. In other words the amount of active material which is originally formed in the plate will depend both on the capacity desired and on the service in which the battery is to be placed.

The Extra Negative Plate.

Q.—106. Why is the number of negative plates in a cell always one more than the number of positive plates.

Ans. 106. If there were just the same number of plates in the negative group as there is in the positive group, a negative plate would be on the outside at one end and a positive plate at the outside at the other end of the cell and the active material on the outside face of each of these plates would be unaffected by the current flowing; that is, this active material would take no part in either the charge or discharge and would soon become badly sulphated. Therefore, in order to get full capacity out of all positive plates an additional negative plate is added so that both sides of all positive plates are covered by a negative. These end negative plates, however, are only ½ plates with the active material formed only on the inner surface next the positive plate.

Rubber vs. Wooden Separators.

Q.—107. What are the advantages of rubber separators versus wooden separators?

Ans. 107. Wooden separators go to pieces more quickly than the hard rubber separators do, but on the other hand, hard rubber separators are apt to break if carelessly handled in cleaning. They are much more expensive than the wooden separators and there is greater liability of a short circuit between plates due to lead tree formation, since an unrestricted opening is provided by the perforations through the rubber separators.

With wooden separators on the other hand, the passage of electricity and diffusion of the acid must be carried on through the cells of the wood fibre. Therefore, so long as the wooden separators hold together there is less liability of short circuits, due to lead tree formation.

Treatment of Wooden Separators.

Q.—108. Most wood contains a certain amount of acetic acid and as this injures the battery in service, it must be removed from the wood separators. What process is employed for removing the acid?

Ans. 108. The process which is employed for removing acetic acid from the wooden separators before they are placed in service is to boil them in a soda or alkaline solution for a long time. This combines with the acetic acid forming sodium acetate, a neutral salt, and this is afterward removed by washing the separators in many changes of water.

Rubber Lining Sheets.

Q.—109. Why are rubber lining sheets placed on the inside of the lead battery tank on all sides of the plates?

Ans. 109. If the rubber lining sheets were not used the plates might easily become shifted over so as to touch the lead lining. This would directly short circuit the plates of this cell and cause it to quickly discharge. In fact the current arcing might be sufficient to burn a hole in the lead lining and cause the tank to leak.

Q.—110. Are these required with a stoneware jar or a hard rubber jar? Why?

Ans. 110. These lining sheets are, of course, not required with a stoneware, glass or rubber jar, in fact they are not required with a jar made of any insulating material since no damage would result if the plates should become in direct contact with the sides of the jar.

Porcelain Base Blocks.

Q.—111. What is the idea in setting the plates on top of two porcelain blocks; why can't they be set right on the bottom of the tank?

Ans. 111. Heavy porcelain base blocks varying from 2 to 3 in. in height are placed in the bottom of lead cells to provide ample depth in the bottom of the cell for the collection of sediment. If this becomes so deep as to touch the bottom of the plates it provides a metallic path for the flow of current between plates and causes the cell to slowly discharge and become sulphated on standing. If the plates were set right on the bottom of the lead tank they would be shortcircuited by the lead lining.

Shop Motor Section

Alternating Current Windings

J. H. Wickman

Up to the present time there has been very little published on the subject of alternating current windings which has not been intended primarily for the use of the designer. In this article it will be endeavored to discuss this subject from the standpoint of the practical electrician and to explain some of the practical methods in use for repairing and reconstructing this class of machinery. No attempt will be made to go into detail or to derive or give formulae for use in alternating current machinery design, such as the construction of rotors and stators, but by means of diagrams and explanations the things that the average electrician ought to know about windings in order to perform his work intelligently and understandingly, will be set forth.

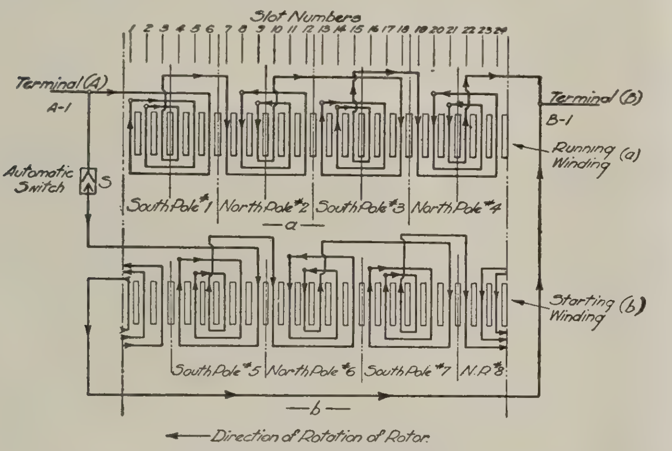


Fig. 1. Winding Diagram of a Single Phase Induction Motor, Showing (a) Operating Winding; (b) Starting Winding.

Whether for use in conjunction with the winding of a direct current armature or the rotor or stator of an alternating current machine, a coil will be understood in this discussion to mean one or more turns of insulated wire, strap, round, or bar, either hand or machine formed, which may be placed into two different slots of the machine being wound. This may be more clearly understood by referring to Fig. 3, (A). The full and dotted coils (C) and (C-1) are composed of many turns of small wire, the terminals of which are lettered (a) and (b). Coil (C) is shown in slots 2 and 5 and bridging 3 and 4. If the armature or stator were spread out to form a plane, as shown in Fig. 3, the coils should be placed in a symmetrical manner, depending upon the type of machine and the form of winding. If the coil were to be placed in groups of three they would then be arranged as shown in Fig. 3 (B), all being connected in series. Another set of these might be arranged in 4, 5, 6, 10, 11 and 12. All coils should be placed in the slots in a symmetrical manner so if coil (c), Fig. 3 (A), is placed in slots 2 and 5, then coil C1, shown dotted, goes into slots 3 and 6.

The size of wire which is used depends on the current which it is to carry and upon the ventilation of the machine and is a matter of interest primarily to the designer. As a rule manufacturers have certain standards allowing a certain number of circular mills cross-sectional area per ampere, which varies from 500 to 1,000, depending on the two factors just named. So no definite rule will be given. When the repair man has occasion to replace burned out windings he should carefully note the size of wire and the number of turns per coil and in this way duplicate the original winding.

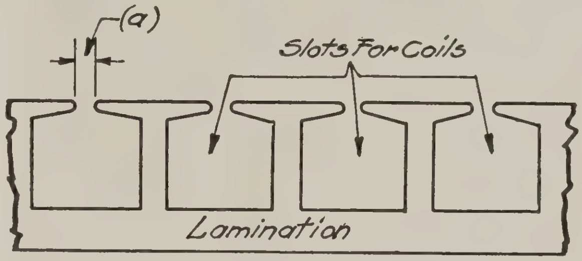


Fig. 2. Field Lamination. Top of Slot Reduced to Improve Magnetic Distribution.

Rewinding Induction Motors.

Inexperienced men should be careful in measuring the size of wire to notice whether or not the turns which form the coil are made up of single large wires or several smaller ones. It has been found that by designing the slots nearly closed at the top that better efficiency can be obtained. Fig. 2 shows that the space at the top of the slot is reduced to a certain width (a) which is too small to allow one large wire having cross section area large enough to carry the rated current to enter the slot. In this case several small wires, having a diameter less than (a) and having a combined area which will give sufficient current carrying capacity, must be used.

Before placing the coils into the slots the ends of the coils which lie outside of the slots are taped with either cambric cloth or lino-tape. Each slot is completely lined with some form of insulating material such as one of those just mentioned, after which the coils can be placed in position.

Effect of Number of Poles on Speed.

In rewinding the stator of an induction motor a rough diagram of the winding should first be made. The number of turns of wire per coil should be noted and also how many slots each coil bridges. In the article on alternating current machinery it was shown that with the speed of the machine and the frequency of the supply both known, the number of poles can be found. For example then, let us consider a single phase, ⅛ h.p., 60 cycle fan motor, designed to operate at 1,800 revolutions per minute. We note that there are 24 slots in the stator. So from the formula

$$P = \frac{F \times 120}{\text{R.P.M.}}$$

in which P is the number of poles and F the frequency, we find that there are 4 poles, which means 6 slots per pole. There are two general methods of winding small single phase motors of this type. One method, which will first be discussed, is known as the concentrated type. It is made up in this case of different sized coils placed within each other as shown in Fig. 1. The form of winding is known to designers as the spiral whole coil type for there are as many groups of coils as there are poles and each group of coils forms a spiral.

Fig. 1 represents the stator of a motor cut open and spread out to form a plane. Or, suppose that a stator such as shown is bent into the form of a cylinder so that No. 1 slot lays parallel and adjacent to slot No. 24. By following in the direction indicated by the arrow heads it will be seen that the current in each of the coils forming one pole flows in the same direction in each coil in the group, and the magnetic effect of the three coils in each group is additive. If the path of the current is followed through the windings beginning at terminal (a) it enters slot 6, then back to slot 1, and slots 5, 2, 4 and out of slot 3, forming south pole, No. 1. Likewise it then enters slot 7, 12, 8, 11, 9 and out of slot 10, forming north pole, No. 2, and in a similar manner south pole, No. 3, north pole, No. 4, are formed and the conductor passes out to terminal (B).

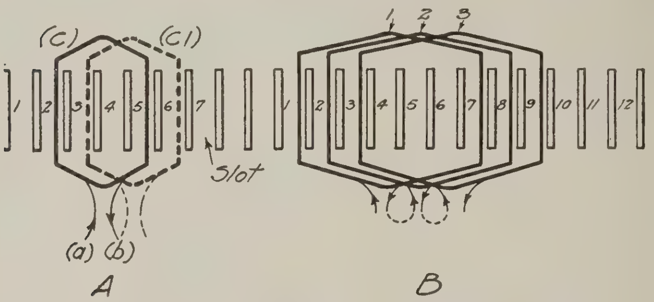


Fig. 3. Showing the Method of Placing Coils in Slots.

Starting Single Phase Motors.

A single phase motor built with a simple winding such as this has no starting torque for no rotating magnetic field is set up, each pole merely becoming alternately north and south with the change in direction of the current. So unless the rotor is started by some outside means the motor will not run.

To make the motor self starting an auxiliary winding is used. This is made of small wire (No. 36 to 40 gauge) having a comparatively high resistance. This is placed on top of the stator winding and is laid in position in the same manner as the running winding as shown in part (b), Fig. 1. This winding is identical to Fig. 1 (a), with the exception that it is laid 90 electrical degrees out of phase with the running winding. It is shown in the drawing as being in separate slots; this is done for the reason that it would be confusing to have one winding shown on the other. The running winding has a comparatively high inductance and the starting winding has a high resistance so the current builds up in the starting winding sooner than it does in the running winding. So when the voltage is a maximum the current is a maximum in the starting winding, making pole No. 5 a south pole, but at this instant the current is just building up in the running winding tending to make pole No. 1 a south pole. So at every instant it is seen that the north and south magnetic poles are moving to the left in the diagram, which means that a rotating magnetic field is set up which will cause the rotor to move in the same direction. After the motor is once started it will continue to run without the aid of the starting winding and as the latter has a high resistance it would heat up to such an extent that it might burn out if it were not protected. For this reason an automatic switch (S) is provided which opens the starting winding circuit after the motor has nearly reached its rated speed. In order to change the direction of rotating of the rotor it is only necessary to reverse the terminals of the starting winding, i. e., the lead (A-1), Fig. 1, would be connected to terminal (B) and the lead (B-1) would be connected to terminal (A).

Some types of small single phase motors like those used for ceiling fans are designed with their windings placed on small pole pieces which resemble the field poles of a direct current machine. These pole pieces are usually designed to the one shown in Fig. 4, which represents one complete pole. The starting winding is placed on the small auxiliary pole wire, the main part of the pole carries the running windings. These poles are so connected that they form alternately north and south poles around the periphery of the stator. The advantage of this form of winding is that the poles can be designed small so that a great number can be used, thus decreasing the operating speed of the motor.

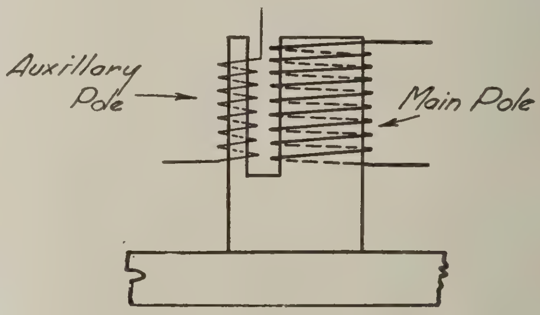


Fig. 4. Method of Mounting Main and Auxiliary Poles Used in Small Motors.

Lap Winding.

Another general method of winding single phase motors is known as the distributed form, which will be considered in future discussions on alternating current windings.

In the example already considered in Fig. 3, suppose that the winding was composed of 24 coils and that two coils were laid in each slot instead of one, with a throw of 7 slots, i. e., the coil No. 1 would be placed in slots No. 1 and No. 7, and coil No. 2 in slots No. 2 and No. 8, etc., around the entire stator until all the coils were in their proper places, making two groups of six coils each. In this form of winding all the coils are of uniform size and form and would be interchangeable. This is known as a lap winding as each coil overlaps the one next to it. The lap winding has the advantage over the spiral or concentrated winding in that only one size of coil is needed, while in the latter, several sizes are used.

The distributed form of single phase winding is usually a standard delta connected three phase winding. That is, two leads from the motor are connected across the single phase supply and the third lead from the motor is connected through some form of a resistance or a reactance which will change the phase relation of the armature current and set up a rotating magnetic field. This lead in either case must be opened after the motor is up to speed, after which it runs on the single phase current as a simple induction motor.

A. B. C. Car Lighting Course

Edited by Edward Wray

Lesson No. 38

Inspection of "Safety" Equipment

While this lesson deals particularly with the Safety type "F" equipment, many of the points taken up will apply equally well to any other type of axle equipment, but in order to be specific we will consider only this equipment at this time.

The inspection of car lighting equipment should be divided into three classes as follows: (1) Daily inspection; (2) Weekly inspection; (3) Semi-annual inspection.

Daily Inspection.

Car lighting inspectors either at division points or terminals should give all equipments a daily inspection whether trouble is suspected or not. If the generator field frame, or if the voltage and series coils of the generator regulator are warm this is a positive indication that the generator has been operating. In this event it is only necessary to inspect the generator main and field fuses, belt, and make test for grounds, as explained under weekly inspection.

If the frame and coils are cold, in addition to inspecting the generator fuses and the belt when testing for grounds, motor the generator in both directions. Motoring is explaned in detail under the weekly inspection and if the generator were motored in both directions it may be passed O. K. If it fails to motor in either direction, however, the trouble should be located and repaired.

The car lighting inspector should have this point strongly in mind: It is far better to be on the lookout for trouble so as to anticipate it and catch it before the trouble causes a failure, than to wait for a failure to actually occur before locating the trouble. In this way many car lighting failures will be avoided and the troubles of the car lighting man greatly reduced. As we all know, the successful operation of any equipment depends on its weakest parts and the inspector should become familiar with these weak parts, such as corroded battery connectors, loose connections on the generator regulator or switchboard, flexible leads that may become almost broken and hanging by only a few strands, dynamo brushes that become gummy and do not move freely, link fuses not screwed up tight, belts that crack in too deep at the clamps to be safe, etc. An equipment with almost any of these troubles might pass the usual tests in the yard but would probably fail on the road. So the car lighting inspector should eternally be on the job to locate such troubles before they actually occur.

Weekly Inspection.

The weekly inspection is intended to cover all necessary repairs for keeping the equipment in operating condition. This requires more time and should be more carefully done than the "once over" daily inspection. The general method of proceeding is as follows:

Remove the generator hand-hole covers and slack off on the belt tension, inspect the commutator and the various wires inside of the machine to see that the insulation is good and that there are no loose connections; turn the armature by hand in both directions to see that the pole changer "throws over" revolving through an angle of 90 deg. on reversal, so that the positive brush comes into exactly the same position the negative brush had been, and vice versa. Also be sure to see that the bearings are O. K. If a ball bearing is defective it will be noticed by a grating or binding as the armature turns.

Motoring the Generator.

The machine should then be motored in both directions. This test requires two men, one being located at the generator panel and the other under the car near the machine. In motoring generator proceed as follows:

First remove the main fuse and test the generator field by closing the automatic switch. This allows current to flow from the battery through the field windings and builds up a strong field magnetism. When the automatic switch is opened this will then disconnect the battery from the field circuit so the energy already stored up in the generator fields will cause a fat spark at automatic switch contact. This indicates that the field circuit is complete, but if there is no arcing as the automatic switch is opened on this first test the field circuit must be open (broken) at some point and *no attempt should be made to motor the machine until this trouble has been corrected.*

Assuming that the field circuit is O. K., the pole changer should be thrown over to either one of its operating positions for if left thrown half way, it would be impossible for the generator to motor. The inspector stationed at the generator panel, after inserting the main fuse, must first strongly compress the field carbon pile by pulling down hard on the inner lever arm; then close the automatic switch by hand and hold it in until the signal is given that the armature is rotating; then slowly decrease the pull on the carbon pile lever. This will allow the field carbon pile to expand which will increase its resistance, decrease the field current and cause the generator to speed up. This release in pressure should be done very evenly so as to produce a uniform acceleration in generator speed, for if done quickly the armature current may become excessive and blow the main fuse.

The Generating Test.

After the armature has obtained a fairly high speed on motoring, open the automatic switch suddenly and pull down on the inner lever so as to strongly compress the carbon pile. This will strengthen the generator field greatly and since the armature is now revolving at a fairly high speed, this will cause it to generate a voltage sufficient to close the automatic switch as is done in normal operation. This last test shows that the lifting coil of the switch has no open circuit or ground. It does not, however, prove that the switch closes at the proper voltage. This can only be determined by the voltage adjustment as explained last month. This test is called the "generating test" and must always be performed in motoring the equipment.

When the armature comes to rest, turn the pole changer to its opposite position by revolving the armature by hand in the other direction about a half turn. Then make the field test, motor the generator and speed it up as above described, finally making the generator test in this direction also.

The inspector should never attempt to motor the dynamo until he has first made certain that the field circuit is complete by the auto switch sparking test and that the pole changer has been placed in one or the other of its operating positions.

Test for Grounds

In order to have any current flow through a ground, there must be at least two grounds, one on the positive side, and one on the negative side of the circuit. A single ground on one side of the circuit only may cause no serious damage. This is always an element of danger, however, and should be removed. Grounds may be considered as of two kinds, (1) metal contact grounds where some part of the metallic circuit makes a direct metallic contact with the frame work or conduit or fixture of the car; (2) battery acid grounds.

The car wiring grounds mentioned first should be immediately removed and the wiring of the car circuits kept entirely free from grounds of this nature. The battery acid contact grounds, however, are of a different nature and as they are frequently of rather high resistance the current flowing in any case will be small. These grounds are almost invariably caused by the wooden tray becoming acid soaked and providing a path for the current from lead lining of that cell to the frame work of the car. There are probably few car lighting batteries operated that do not have a ground of this nature, though in most cases this being of such high resistance that the current flow is only a fraction of an ampere and not dangerous to the battery.

Car Circuit Grounds.

A ground caused by a worn or defective insulation in the car wiring or in the generator will usually be indicated by the main circuit or the battery circuit fuses being blown repeatedly on the road, or as soon as the battery is placed on charge in the yard. Some grounds, however, may not be of sufficiently low resistance to allow the grounded current to exceed the capacity of the fuses, so a weekly test for grounds should be made as follows:

With the test lamp and socket equipped with two short leads, connect one side to the positive lamp terminal on the regulator panel and the other lead to a bright metallic surface on the conduit or car frame. Close all light and fan circuits and if there is a ground on the negative side of the circuit, the test lamp will light up. Then switch the terminal to the negative generator and if it fails to light up it indicates that the positive side of the circuit is clear. Or if it lights up it shows that there is another ground in the positive side. Note that the ground, where the volt-meter or test lamp is used, is always on the opposite side of the circuit from the terminal connected to the test lamp or volt-meter; but where a magneto is used, the ground is always on the same side as the circuit being tested.

The volt-meter test will indicate a ground even if it is of a very high resistance and of no consequece. The test lamp, however, is an indication of the quantity of current flowing to ground and on high resistance grounds, such as would affect a volt-meter, the test lamp will not light up at all. Where a ground is of some consequence, such as would allow one or two amperes or more current to flow, the test lamp will light up more or less brilliantly. If it is a dead short circuit to ground the test lamp will light up to full brilliancy. Where a ground which will show up on the test lamp is discovered it should be cleared immediately whether it is on car wiring or the battery. A ground on the car wiring can be located as follows:

After closing all lamp and fan circuits, open them one by one, testing for grounds after each switch is opened. If the ground fails to show up at any time it will be found on the last circuit opened. If a ground still exists after all switches are opened, open the generator negative at the regulator panel and if it now fails to show up it indicates that the ground is somewhere on the generator or under car wiring between the negative terminal just opened and the generator, or between the generator and the automatic switch. If a ground still exists it may be on the car wiring between the regulator panel and battery, or on the battery itself. So go to the battery and connect the test lamp between the ground and the terminal which will light the test lamp, then disconnect the opposite battery terminal from the car wiring and if the test lamp now fails to light up it indicates that the ground is somewhere between the battery and the regulator on that side of the car wiring circuit which has been opened.

If the ground still shows up it is on the battery itself and the exact cell on which it occurs can be determined by the voltmeter test, as described under "Volt-Meter Test for Battery Grounds" in this lesson. After the battery ground has been cleared, again connect the terminals to the car wiring and close all switches on the regulator panel and again test for grounds on both sides of the circuit. If another ground shows up, go through the same procedure until it is located and until the test shows all circuits cleared.

Testing with Magneto.

The test for grounds in the car wiring may also be made with a magneto, as follows: Disconnect both terminals of the battery from the car wiring at the battery box. Leave the automatic switch open, for if it is closed it will connect both sides of the circuit together through the dead armature coils which have low resistance. Never use a magneto when the battery is connected to the circuit, for with a heavy ground, the battery current might be sufficient to burn up the magneto.

Connect one lead of the magneto to the negative terminal with all lamps and fan circuits closed and the other magneto lead to a bright metallic surface on the conduit or car frame. Then turn the magneto and if it "rings a ground" it indicates that at some point on the negative side of the car wiring or on either the positive or negative side of the generator or under car wiring circuits there is a connection to ground. Since the negative generator terminal and the field negative are both permanently connected to the negative car circuits the entire generator circuit on both positive and negative sides and the positive lead back to the automatic switch, will then be on the negative side of the circuit being connected through the dead armature coils. Then transfer the magneto lead from the negative to the positive terminal and test again with all switches closed. If it is possible to ring the magneto on this side also it indicates that there is another ground somewhere on the positive side of the circuit.

After a ground has been located on either side or both sides of the circuit, open all switches and test each circuit separately until the ground is located, then clear the ground in such a manner as to prevent it occurring again.

If a ground is found by ringing the negative generator terminal at the regulator panel it indicates a ground either on the under car wiring positive or negative, or somewhere in the generator itself. In order to clear this, go below and open the generator terminal connector which will entirely disconnect the generator from the regulator. Then ring out again the negative terminal on the regulator panel and also the positive generator terminal at the bottom of the regulator panel. If it is impossible to ring the magneto to ground on either of these circuits, it indicates that the under car wiring is clear. But if it is possible to ring the ground on one side of the circuit it should be located at this point and cleared.

Next go to the generator and connect one lead of the magneto to the negative generator terminal and the other to a bright metallic surface on the generator frame or car wheel. This will test both the positive and negative sides of both the armature and field circuits. If you get no ring here it indicates that the entire generator is clear. But if it is possible to ring a ground, raise all the brushes and insulate them from the commutator by inserting a piece of paper. Then ring out separately the generator field circuit and the commutator and the brush holders, until trouble is located and cleared, and until all circuits show no ground.

Battery Grounds.

Battery grounds are of much more common occurrence than car wiring grounds, in fact there are few batteries in car lighting service which do not have a ground of some kind. A battery ground is almost invariably caused by the wooden tray becoming acid soaked and with the insulators either soaked with acid, as they usually are, or having rollers cut deep into the wooden floor of the battery compartment, so that the hubbs touch the floor, a direct acid connection to ground is thus provided. This acid connection, however, is not of low enough resistance to blow any fuse, but it may allow sufficient current to flow to seriously discharge the battery on standing and, what is of more importance, it will cause the lead lining of the tank at the ground which is nearest the positive end of the circuit, to pit and if this ground is not soon cleared will cause the tank to leak.

A battery ground should not be considered very serious unless it shows up on the test lamp in testing between battery positive and ground and battery negative and ground. It must be remembered, however, that a heavy ground at the middle part of the battery will only give half voltage on the test lamp at either terminal.

Where a heavy ground shows up on the test lamp, the cell upon which it occurs can be located as follows:

Connect a volt-meter between positive and ground and also between negative and ground and if it is found that there is, say, 8 volts between positive and ground and 24 volts between negative and ground, the ground will be found on the fourth cell from the positive end, as shown in the accompanying diagram. Sixteen volts on each side would indicate that it is on the eighth cell from the positive terminal. The question of battery leakage between adjacent cells will be discussed next month.

After all grounds have been removed the equipment should be reconnected properly and the machine motored out again. The inspector should remove any accumulation of dirt or grease from the interior of the machine and particularly from the brushes, brush holders and commutator; sand paper should be used on the commutator only when absolutely necessary; never use emery paper, as this will coat the brushes with emery dust which will make them wear into the commutator. The inspector should then examine all flexible leads, brush pig tails and other interior wires for defective insulation, repairing any such defects and finally arranging all such wires and flexible connections so that the rotation of the pole changer will not cause them to rub on the generator frame, hand hole covers, or armature, as a large part of the trouble in defective insulation is brought about by such rubbing.

The hand hole covers should then be properly secured and the pulley should be rotated by hand in both directions to see that the pole changer flexibles do not foul. The belts should be so placed that the clamp falls on the generator pulley so as to facilitate its inspection, and the belt tension should then be adjusted to proper value. Be sure that the belt is not cracked at the fastener so as to endanger its operation. Many belt failures can be removed by catching the belt when it first begins to crack. Cut off the damaged portion of the belt either shortening the belt or putting in a new piece, as may be necessary.

Regulator Panels.

Regulator panels should also be inspected weekly to see that all connections are tight and that all moving parts operate in the proper manner. It may be necessary to remove and to clean the carbon piles, in which case the proper number of carbon discs must be replaced. Never sand paper the carbons; if they are found to be defective, replace with new carbons.

Regulator adjustments must not be changed unless it is known that existing adjustments are incorrect and care must be taken not to alter the tension of any of the springs by stretching or other rough handling. The dash-pots of these regulators are of the air dash type using graphite plungers. These plungers must be handled very carefully as they will chip very easily and once the surface is damaged it will cause the dash-pot to bind and prevent it working freely. The parts of these dash-pots are not interchangeable as the plungers are fitted to an accuracy of 1-1000 of an inch. If a plunger or other part of the dash-pot becomes broken it is necessary to forward the complete dash-pot and plunger to the manufacturer for repairs and replacement.

Semi-Annual Inspection

This periodical inspection should be made at intervals of about every six months and involves a general overhauling of the entire equipment on the car. For a proper inspection the generator must be more or less dismantled so that all parts may be cleaned and examined. This dismantling of parts should be continued only to such a point as will insure that all defects have been discovered and repaired and that the equipment is placed in a first class condition. This inspection can best be performed by entirely removing the equipment from the car and mounting it on a test rack in the shop where the generator can be driven by means of a variable speed motor. The following gives in detail the procedure to be followed in completely dismantling the equipment.

Dismantling the Generator.

Remove the belt and hand-hole covers and "motor out" in both directions, making a "ground" test as required in the Weekly Inspection, these operations being for the purpose of detecting faults in the generating apparatus.

The commutator end head, both bearings, pole changer and brush rigging, and armature should be removed, carefully looked over, and if found in good condition, cleaned and the machine reassembled. The felt washers on the pulley end grease cap, pulley end head, commutator end head, and pole changer should be carefully examined before re-assembling the machine.

Removal of Armature.

To remove the armature, first slack off the belt tension; then remove grease cap at the commutator end, and take off nut on end of shaft. The head and ball-bearing with its sleeve can now be removed. To do this, take out the six cap bolts which hold the head to the frame, and screw two of the long bolts into the two tapped holes in the head, forcing the head from the frame. The ball-bearing on its sleeve will come away with the head, disclosing the pole changer, which can be slipped off the shaft with the brush rigging after the flexible leads are disconnected from the brush rigging. Take off the pulley locknut and remove pulley and pulley end grease cap. Remove spring lock from the bearing locknut, and unscrew locknut. The armature can now be taken out from the commutator end; care being taken not to drag the armature on the poles. The bearing with hub can now be removed from the head.

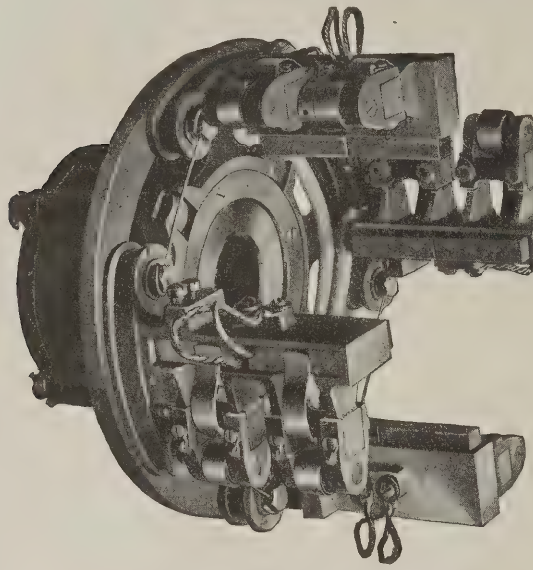


Fig. 197. Pole Changer Brush Rigging Brushes Mounted in Place.

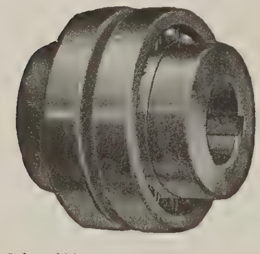


Fig. 198. Ball Bearings for Brush Rocker.

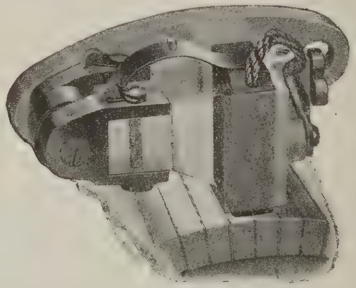


Fig. 199. Brush Box and Brush Pressure Spring.

The machine frame is to be cleaned of all dirt and grease and a thorough inspection made of the field coils, which are to be removed if oil soaked or otherwise defective. Removal of field coils shall be made at the direction of the foreman electrician or his inspector.

Field Coils.

To remove the field coils open all the coil connections then remove the four brass coil retainers by removing the nuts from the corresponding pair of bolts in each retainer. Next remove the pair of bolts from each field pole after which the pole shoes and coils can be easily taken out. To replace the coils reverse the above operation.

When applying new coils it is absolutely necessary that proper connections be made, otherwise the generator will not operate. All coils are stenciled with the letters "I" and "O," signifying "Inside Lead" and "Outside Lead," respectively and when properly applied, the "I" end of each coil will be at the commutator end of the machine. In making connections between the various coils, the "I" lead of the upper righthand coil (as the observer faces the commutator-end of the machine), connects to the positive field lead passing through the bushed hole in the machine frame. The "O" lead of the same coil connects to the "O" lead of the upper left-hand coil (connection to be made at the pulley end of the machine) and the "I" lead of the upper left-hand coil connects to the "I" lead of the lower left-hand coil (connection to be made at the commutator end, and so on to the "I" lead of the lower right-hand coil, which is to be connected to the negative terminal block on the machine head. All joints in the field circuit must be taped, then waterproofed with shellac or other suitable insulating and waterproof compound.

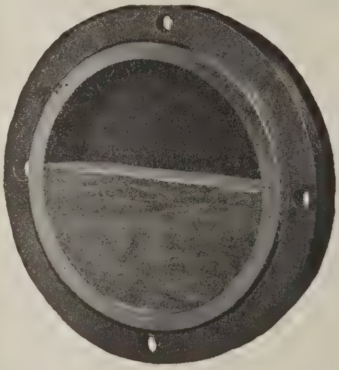


Fig. 200. Commutator End Grease Cap Showing Proper Amount of Grease.

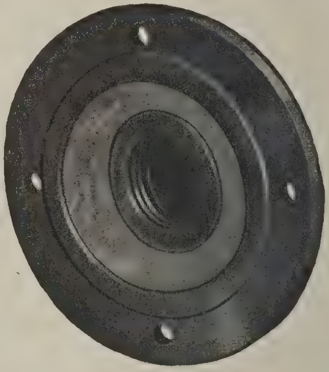


Fig. 201. Pulley End Grease Cap with Grease, Ready for Application to Dynamo.

The generator terminal blocks on the inside of the frame should be inspected to see that they are tight.

The brushes should be removed from the boxes and the brush rigging wiped off with gasoline. The heads, pole changer and all ball-bearings should be thoroughly washed with kerosene. Never use gasoline for washing these latter mentioned parts.

To remove ball-bearings from the pole changer, take off nuts at end, when the end cover will come off and bearings will slip out of the housing. After washing its bearings the pole changer should be immediately re-assembled, care being taken to make the retaining nuts tight and to replace the cotter pins. Before slipping the bearings in the housing, grease should be packed into and between the bearings. No attempt should be made to separate any of the ball-bearings from the hubs on which they are mounted.

With generators having the old style pole changer, to separate the pole changer from the head it is necessary to remove the "snap ring" at the inner surface of the head. Once the pole changer is removed it can be taken apart by laying it with brush-holders down, and removing first the four screws which secure the ball retainer ring to the ball-race collar, then the balls and finally the brush-holder ring from the ball-race collar. The connecting wires of the various brush-holders can be inspected for defective insulation by removing them.

Bearings after washing, should be drained and then wrapped in clean cheese cloth until the machine is ready for their application.

To reassemble the machine, slip the armature in frame through the commutator end. The pole changer and brush rigging can then be slipped over the shaft, and the commutator head applied. In applying the commutator head, care should be taken to see that the stop for the pole changer on this head is at the top and that the pole changer is applied in such a position that the stop on the head will limit the travel of the pole changer to 90 degrees. The ball-bearing at this end should then be applied and the locknut made up tight, and the cotter pin replaced.

Before applying bearings and pole changer to shaft, a coating of graphite mixed with oil should be applied to the surface of the shaft.

Ball Bearings.

Ball bearings are lubricated with a heavy grease instead of oil as customary with plain bearings. This grease must not be applied too frequently nor in too large quantities, as any excess will ultimately creep into the machine and cause trouble.

The amount of grease found in the commutator-end grease cap upon removal of the latter is not a good indication as to whether or not additional grease is required, as the workman has no means of knowing how much lubricant remains in the bearing and in the space between the bearing and the head.

There is normally no tendency for grease to escape unless an excess quantity be applied, so except in special cases, it is necessary to lubricate the bearings only when the machine has been dismantled for the semi-annual inspection, at which time all the old grease should be thoroughly washed out of the bearings and other parts with kerosene. After the grease caps have been so washed out, they should be filled with grease as follows: The commutator-end cap to be filled to a height of two inches; the pulley and cap to have its annular space completely filled, as shown in Figs. 200 and 201.

The pulley should then be replaced and securely locked with locknuts. Care should be taken to make up all nuts tight and secure with the locking devices.

The flexible connections should be connected and the brushes replaced in the boxes, after which the dynamo should be motored.

The regulators are also to be over-hauled and cleaned but their adjustments must not be changed unless it is known that existing adjustments are incorrect. Workmen must be careful to not injure the springs, graphite plungers of the dash-pots, or the carbon discs.

The generator suspension belt and axle-pulley should be thoroughly gone over, and all loose nuts, bolts, studs, rivets, bushings and set screws made tight. Any part which shows serious wear should be renewed.

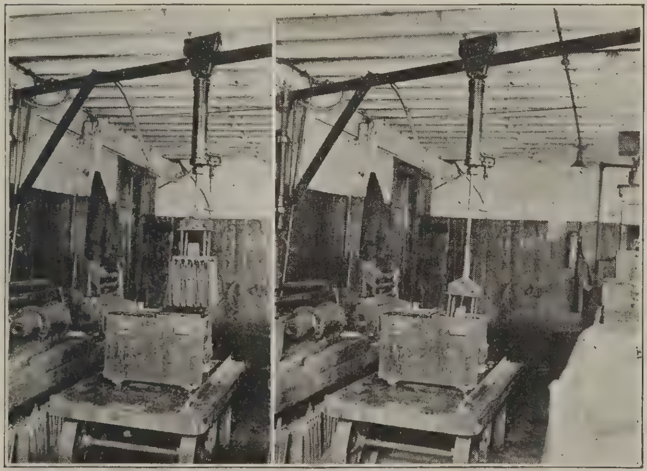
Practical Stunts

We Pay a Dollar Apiece for Practical Stunts—Send in Your Ideas

Battery Handling Crane

A new battery crane has recently been placed in service at the Chicago yards of the Rock Island lines, and this will no doubt be of interest to other car lighting men.

A 3-in. air cylinder with a 16-in. stroke was located in the scrap pile at the blacksmith shop, and after being fixed up a little was found to be serviceable. This was mounted on a heavy sliding door hanger with double flanged wheels which run on a ⅝-in. steel bar as a track. This steel beam, ⅝-in. thick and 3½ in. deep, is set edgewise, and is supported by a diagonal brace of the same material, and both are made with an eye hole at the end, which circles the pivot bar. A tension rod riveted to these bars completes the truss. The span of the brace on the pivot bar is 54 in. Three heavy straps (old type "C" Consolidated rocker shoes) anchor the pivot bar of the crane to one of the 8-in. posts of the building. The pivot bar is an old Safety rocker shaft.



Showing How the Battery Tray Is Used to Lift the Plates Out of the Battery Box.

A special gripping device for picking the elements out of the tanks was made. This consists of two pairs of double fingered hooks loosely mounted in and supported by two short angle bars. These steel angles are bolted together with a center supporting plate and insulation between. The insulation is added, of course, so that the hooks will not short circuit each particular cell as the plates are being removed. These hooks are covered with rubber tubing with the end sealed with vaseline, so that the iron will not be attacked by the acid and cause iron impurity to get on the elements of the cells being cleaned.

As the 8 trays of a 32-volt battery are brought in on a truck the covers and connectors are first removed, and the elements can then be easily jerked out by inserting the four fingers under the plates and turning the air cock of the plunger. The elements can be raised to any height desired by turning on more or less air, and a slight push will easily cause the beam to swing around or the carriage to roll on the track, so as to bring the elements over the cleaning table, or any other point desired, when the air valve can be released and the elements lowered. This all operates very quickly, in fact, one husky man is able to raise and lower a set of elements without ever changing the air valve. This is done by simply adjusting the air pressure so that the plunger will almost lift the elements, and an additional boost by hand will jerk them out and raise them so they can be swung over to the cleaning table. He then gives the elements a push down and releases the hooks, and the operation is repeated.

This battery crane has greatly improved the speed and ease with which batteries are handled in being cleaned.

Adjustable Shunt for C-2 U. S. Panel.

I will describe a scheme that I discovered while experimenting on a C-2 U. S. panel. As you know, the C-2 panel is not equipped with an adjustable shunt to reduce the current flow and in most cases where this panel is used the total charge is much in excess of the total discharge. Now this causes the battery elements to warp, so some means had to be devised to reduce the output of the generator. The stunt is very simple and is as follows:

Remove the small fuse from the C-2 taper charging relay and replace with about 12 in. of No. 22 German silver wire. This will reduce the current output to about 10 amperes and, of course, the longer the wire the greater the current reduction. I always carry some of this resistance wire with me and wind it around a pencil to make a small resistance unit. Its operation is as follows:

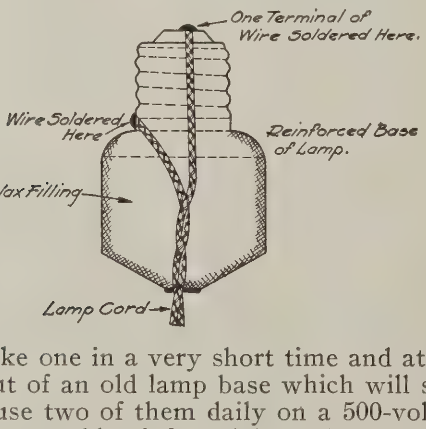
Normally the flow of current is shunted around the modifying coil in the main solenoid through the fuse to the C-2 taper charging relay. Now, by inserting this resistance, as explained above, in place of the fuse there will be a small amount of current allowed to pass through the modifying coil, thereby decreasing the pressure on the field carbons in excess of that caused by the operation of the series coil. On test it shows that the nearer the battery is to complete charge the more the charge is reduced, caused by the voltage in the coil rising.

I am sure that this little stunt will save many dollars in battery failures.

D. C. Houston, Frisco Lines.

Homemade Plug For Extension Cord.

Every electrician in his work has daily need for an extension cord both for inside and outside work for use with fans, vacuum cleaners and in various tests. The ordinary extension plug used on such cords costs from supply stores, about 25c. Now here is a good way to make one in a very short time and at very little cost, out of an old lamp base which will stand the test, as I use two of them daily on a 500-volt circuit. If you take an old reinforced lamp base and remove all the glass and filler from the base and proceed as follows, a very serviceable plug can be made:

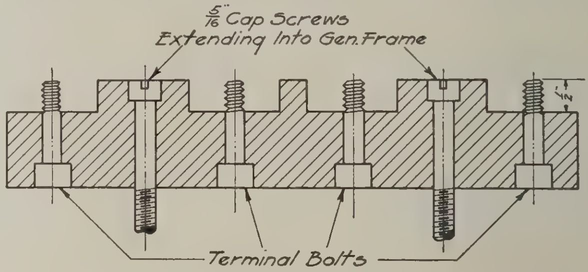


Drill a small hole (about 1/32 in.) through the end after removing the pieces of internal wiring; then, with a piece of lamp cord, put one conductor through this hole in the top and solder it in place. On the outside edge there is always a small hole through which you can run the other wire, or, if there is not, it is very easy to drill one. Insert the wire and solder in place. The base is then ready to be filled with wax. If an insulator is placed around the wires at the point where they leave the wax, the job may be made more substantial.

H. N. Bohlen, Atlantic Coast Lines.

Broken Terminal Block.

In tightening up the nuts on terminal blocks it very often happens that the terminal bolt is broken, which necessitates the removal of the armature to make the repair, causing the loss of considerable time. When such a thing happens, remove the entire terminal block and in place of it fasten a block made similar to the one shown in the accompanying sketch. Fasten this 2 in. below the position occupied by the terminal block with 5/16-in. cap screw. Place felt between the block and the machine, then splice the wires inside the machine and bring them through the machine in the insulated holes and attach to the applied terminal block. If a terminal bolt now breaks off the repair may be finished in little time by removing the two 5/16-in. cap screws and inserting a new terminal bolt.

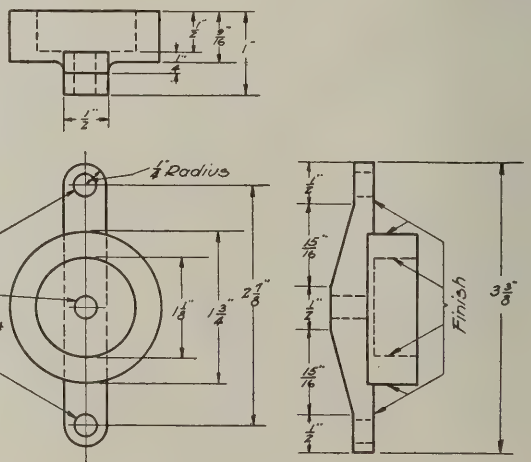


J. E. Millard, Topeka, Kans.

Tail Rod Guide For Bliss Regulator.

We have experienced considerable trouble with the No. 10364 tail rod guides used in connection with the U. S. L. lamp regulators. These have worn out in a very short time and after attempting to make repairs in various ways, we decided to make one of our own, a sketch of which is shown in the accompanying figure.

The guides, as made by us, are of cast bronze and cost us about 25% less than the standard guide and will outwear at least a dozen of them. For the correct operation of this guide it is of course, quite essential that the stem of the plunger, which passes through the guide, be perfectly straight in order that it may not bind.



M. F. Hand, Santa Fe, Topeka, Kans.

With the Manufacturers

Axle Generator Terminal Box.

The No. 500 Central Terminal Box is made of cast iron black enameled. It is 6″ wide, 6″ high and 2¼″ deep. On the upper end is an outlet threaded inside for an inch and a quarter pipe. On the lower end is a removable cast iron piece threaded to take an inch and a quarter pipe. By making this lower end piece removable it is possible to disconnect the wires and remove the generator or move the box without withdrawing the wires.

Fastened on the inside of the back of the box is a piece of hard maple saturated with weatherproofing compound into which are moulded three terminal posts—two for current and one for field wires. These posts are of different diameters being respectively—¼, $\frac{5}{16}$ and ⅜ of an inch, and the posts are designed to take lugs with holes of corresponding size, thus making it impossible to make a wrong connection. Suitable fastenings are provided to securely clamp the lugs which have been soldered to the wire, so that an extremely rigid and strong connection is provided without soldering.

New Central Electric Generator Terminal Box With Flexible Steel Hose Conduit Connection.

There is a cover on the box which can be readily removed by taking out two screws. The box is neat in appearance, thoroughly weatherproof and serviceable and should be a part of every axle-lighting equipment.

Amperehour Meters for Pullman Co.

The Sangamo Electric Company of Springfield, Ill., has just closed a contract with the Pullman company for several thousand amperehour meters. This is the second large contract for this type of meter given the Sangamo company by the Pullman company. As rapidly as possible, each and every Pullman, sleeping and parlor car is being equipped with a Sangamo amperehour meter, to control the battery charge by the method developed by Ernest Lunn, chief electrician of the Pullman company.

The application of Sangamo amperehour meters during the past year on hundreds of Pullman cars has resulted in greatly improved conditions of battery operation, and this improvement in turn is responsible for the Pullman company's decision to equip all cars in this manner.

The Transcontinental Voice Highway.

"Hello, Frisco!"

"Hello, New York!"

This interchange of spoken communication between the great metropolis of the West and the great metropolis of the East was proclaimed to the world on January 25, 1915, as an accomplished fact, and one dream of the telephone engineer realized. It means direct speech between two points 3,400 miles distant, telephonically speaking, over wires that traverse mountains, valleys, deserts and lakes, a line whose direction involved the most difficult problems met with since the inception of the telephone in 1875.

In 1849, transcontinental travel consumed five months by stage coach. In 1859, by sailing vessel around Cape Horn it required three months to reach San Francisco from New York. Ten years later the railway bridged the distance in twenty days. The opening of the Panama Canal in 1914 made it possible to do the journey in sixteen days by steamship, while the beginning of 1915 shows a railway record of 71 hours and 27 minutes, with an average time of 90 hours. By transcontinental telephone line a man's voice and personality reach the far end in one-fifteenth of a second.

It is worthy of note that this transcontinental voice highway has been completed and given over to public service during the lifetime of Alexander Graham Bell, the inventor of the telephone, and it seems most fitting that he was the first man to talk over it to that other man, Thomas A. Watson, who, as Professor Bell's assistant, heard the first words ever spoken into a telephone.

To make ocean-to-ocean talk possible, it has been necessary to do a well-nigh perfect piece of line-construction work. The external evidences, poles and wires, important as they are in themselves, give only the faintest ideas of the years of ceaseless research and experimental work by the American Telephone & Telegraph Company that have resulted in this talk-link between west and east, an accomplishment representing the last word in telephone science. With this study has come the improvements in line construction, cable, receivers, transmitters,. switchboards and all the other telephone apparatus needed to send the delicate electric voice currents over the 3,400 miles that separate New York and San Francisco and deliver them at either end undiminished in volume and undistorted.

An idea of the quantity of the line material used may be gained from the fact that there are four copper wires each 3,400 miles long and of No. 8 B.W.G. gauge, producing a total weight of 5,920,000 pounds or 2,960 tons. In the line itself there are 130,000 poles.

The Western Electric Company which supplied all of the line construction material and telephone apparatus used in conjunction with this transcontinental voice highway has issued an attractive folder showing a map of the line, views taken during its construction and reproductions of drawings and photographs depicting the opening of the first long-distance line between Salem and Boston, Mass., in 1877, the line between New York and Chicago in 1892, and that between New York and Denver in 1911.

Portable Fault Localizer.

A portable fault localizer, for quickly locating a ground on a power cable is now being marketed by the Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. The position of a ground is read directly off the dial in terms of per cent of length of defective cable. It is an application of the wheatstone bridge with all the necessary apparatus contained in one portable case wired for connection to the circuit to be tested. Its use assumes that the cable is grounded at one point and that a parallel conductor of the same length and resistance as the faulty cable is available.

After proper connections are made, a dial on the instrument is revolved by means of a knob in the middle of the localizer until the galvanometer shows no deflection when the key is closed. The reading of the meter then gives the percentage of length of the feeder from the point where the test is being made to the location of the ground, assuming the total length of the feeder to be 100 per cent; the red scale indicating that the ground is on the conductor connected to the binding post marked red, and the black scale indicating to the binding post marked black.

Westinghouse Portable Fault Finder.

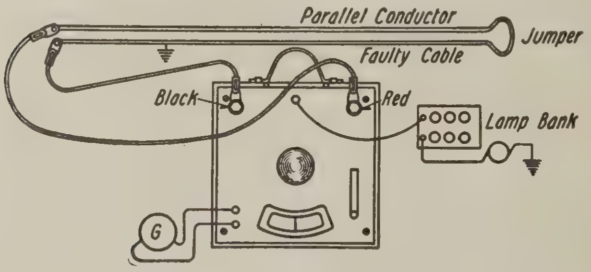


Diagram of Connections For Using Fault Localizer.

Direct current only is used in these tests.

The fault localizer consists of a polished wooden case which contains all the parts necessary for the test except the source of direct-current supply and the leads to the cables. Two styles are furnished, one containing a galvanometer and the other for use with a separate galvanometer.

The variable resistance arms consist of two loops of low resistance wire attached to the side of a revolving disc, upon which the dial is attached, so that contact is easily made from two brushes attached to the case and connected to the galvanometer terminals. As the disc is revolved the point of contact between the brushes and the resistance loops is thus varied, as in the slide-wire bridge. The dial is calibrated in percentage of the length of the conductor tested, so that the reading is direct.

The galvanometer is highly sensitive, having a "unipivot" bearing which does not have to be leveled to take readings. It can be used for general testing wherever a portable galvanometer of its sensibility is desirable, and can easily be removed from the case when this is desired. It has a resistance of 5 ohms, full scale readings .00036 ampere, and sensibility .00001 ampere division.

Result of Recent Car Lighting Patent Litigation.

Two suits by the Safety Car Heating & Lighting Company against The United States Light & Heating Company have recently been decided in favor of the defendant by Judge Hazel in the Western District of New York. These suits were on the W. I. Thompson Patent No. 881,743, March 10, 1908, on a Dynamo Suspension for Car Lighting, and W. I. Thompson Patent No. 926,518, June 29, 1909, on a Lighting System commonly referred to as the Carbon Disc Regulator. In each case the patent was held invalid and the bill of complaint dismissed. The Court held that the predecessors of The United States Light & Heating Company had installed dynamo suspensions and the carbon disc regulator substantially as described and claimed in the patents, on their own apparatus on the New York Central Railroad prior to the dates of the patents.

On December 10, 1914, Judge Hazel of the Western District of New York, handed down a decision in the suit of the Safety Car Heating and Lighting Company vs. the United States Light and Heating Company, holding patent No. 747686, issued to J. L. Creveling, and owned by the former company, valid and infringed by the apparatus of the latter company. There were eight claims in the suit and all were sustained.

The patent covers regulating devices for regulating the output of a variable speed generator and means for controlling the regulating devices to determine the output.

Equipment for Pennsylvania Electrification.

Eight cars intended for use on the electrified line of the Pennsylvania Railroad between Philadelphia and Paoli have been received at the West Philadelphia yards of the company. It is announced that work on the rest of the ninety cars to be used on the main line electrification will be completed by April 1. The work of stringing wires and erecting poles is more than 65 per cent completed, and under favorable conditions it is expected that electric service will be started in June.

Test of Norfolk & Western Single Phase Locomotives.

Successful tests have been terminated on the powerful single phase locomotive built by the Westinghouse Elec. & Mfg. Co., for use on the Elkhorn division of the Norfolk & Western Railway. The weight of the locomotive is 270 tons and it has sufficient capacity to move a 250 car train on a level track. To facilitate the handling of the trains and to lessen the danger of break-in-twos one locomotive is used at either end of the train. The electric braking has been accomplished by reversing the poles of the motors, causing them to act as generators, thus holding the train at the desired speed without the use of brakes. Single alternating current at 11,000 volts is used.

The details of the traffic on the electrified section were described in the February issue of the RAILWAY ELECTRICAL ENGINEER. There will be handled on this line from 50,000 to 100,000 tons of coal a day.

National Joint Committee on Line Construction.

The fifth meeting of the National Joint Committee on Overhead and Underground Line Construction was held Wednesday, February 24th, in the rooms of the American Institute of Electrical Engineers, at No. 29 West Thirty-ninth Street, New York City.

The Committee devoted practically all day to continuing the work of the revising the present power wire crossing specifications, and dividing the work up into sections, to be apportioned to various sub-committees for revision.

The Committee would greatly appreciate advice as to desirable requirements, and also detail criticism of any of the clauses of the present standard power wire crossing specifications.

The meeting was called at 10:30 A. M. and adjourned at 5:30 P. M. to meet March 31, 1915.

New Handbook for Electrical Engineers.

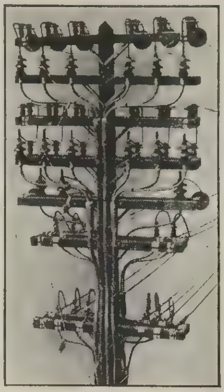
The American Handbook for Electrical Engineers, published by John Wiley and Sons, of London, now stands out as one of the best works of its kind on the market. Not only does it treat of all the subjects embraced under the head of electrical engineering, but it also includes other material of use to the electrical engineer. It should prove of immense value as a reference book to an engineer engaged in any branch of electrical engineering. It contains 2,023 pages of printed matter but yet is not large enough to be bulky.

The method of arranging the material is new in that all subjects are treated alphabetically rather than being arranged in groups as is usually the case in such works. This may at first be confusing to engineers who are used to the group method of classification and whether or not it is a success will depend upon the way that it is received by the profession.

Dr. Harold Pender and his able assistants are to be congratulated upon their work. It should prove of great value to the operating engineer after he has become familiar with the arrangement of the material.

International Engineering Congress.

The American Society of Mechanical Engineers had issued a circular letter to its members, urging them to subscribe to the International Engineering Congress to be held in San Francisco in connection with the Panama-Pacific International Exposition, Sept. 20 to 25, 1915. As one of the five national societies in the hands of the representatives of each of which the Congress is placed, it is urged by the mechanical engineering society that its members should feel responsibility and give their fullest support to the Congress. The fee for membership is $5, which entitles a member to the index volume which covers the general proceedings, indexes and digests, and any one of nine volumes which are published or to be published, as follows: Vol. 1, The Panama Canal; Vol. 2, Waterways and Irrigation; Vol. 3, Railways; Vol. 4, Municipal Engineering; Vol. 5, Materials of Engineering Construction; Vols. 6 and 7, Mechanical and Electrical Engineering; Vol. 8, Mining Engineering and Metallurgy; Vol. 9, Naval Architecture and Marine Engineering; Vol. 10, Miscellaneous.



The Best Engineering Practice

in the installation of lead-covered cables of all kinds requires that the same care be given to protecting the insulation against moisture, etc., at the ends as at the joints in the manholes.

STANDARD
D. O. A. and D. S. Cable Terminals

provide this protection and their many exclusive and patented features have been suggested by our over 30 years' experience in the manufacture and installation of lead-covered cables of all kinds.

Bulletins Nos. 700 and 710 give valuable engineering data about terminal construction and installation.

Write our nearest office for copies.

Standard Underground Cable Co.
PITTSBURGH, PA.

Boston Philadelphia Chicago
New York San Francisco St. Louis

Manufacturers of Electric Wires and Cables of all sizes, for all services, also Cable Accessories of all kinds.

TRAVELING DAYLIGHT
AMERICAN STEEL SPLIT AXLE PULLEY

AMERICAN Pulleys contribute much to the comfort and luxury of modern travel. The floods of brilliant daylight in many Pullmans and passenger coaches, find their birth in AMERICAN Steel Split Axle Pulleys—applied almost instantly. Full explanation of advantages in the catalog.

The American Pulley Company
Philadelphia
New York Boston Chicago

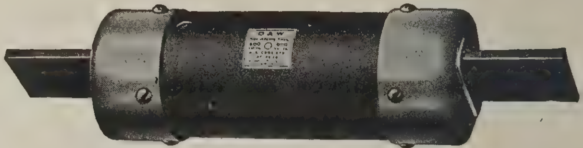
"The House

Your entire requisition for electrical supplies with one order and you receive the goods in

The ALEXALITE is the last word in efficient office lighting. Ask for details.

A Customer Says:

"The 400-watt lamps with large base came in today and we are now enjoying a perfect office light, no dark corners, no shadows, no eye strain. Like so many other good things common today, but unknown to a previous age, we don't see how we got along without it. Will certainly make use of more ALEXALITES when opportunity offers."



Every Blown Fuse Is An Expense

Every fuse that blows *under its rated capacity* is an *unwarranted* expense.

Many do not analyze the causes that add dollars to their fuse bills.

Defective interior construction, weak joints and imperfect alignment of blades cost fuse consumers hundreds of dollars a year.

Consider These Points In "D & W" Construction

The links are scientifically designed.

Every joint is *rivited* as well as soldered. They won't let go.

The blades are properly aligned. Excessive heating is eliminated.

All metal parts are ample and are securely fastened to the tube.

"SPECIFY D & W"
And Get More Fuse Value.

Central Electric Company

320-326 So. Fifth Avenue Chicago

RAILWAY ELECTRICAL ENGINEER

Official Journal
of the Association of Railway Electrical Engineers.
PUBLISHED MONTHLY BY
WRAY PUBLISHING CO.
EDWARD WRAY,
President.
C. D. SPERRY.
Editor.
ADVERTISING BLDG.—123 W. MADISON ST.
CHICAGO.
Telephone, Randolph 7414.

Entered as second-class matter, August 6, 1909, at the Post Office at Chicago, Ill., under the Act of March 3, 1879.

Terms of Subscription

United States, Canada and Mexico	Per Year, $1.00
Foreign	Per Year, $1.50

Table of Contents

Page

Editorial:
- Under Frame Suspension of Car Lighting Generators .327

Automatic Block Signal System for Shop Traveling Cranes, By E. Wanamaker .328

Operating Results of Steam Railroad Electrification .332

Electrification of Swiss State Railway Electrification .336

Shop Motor Section:
- Three Phase Windings for A. C. Machinery, By J. H. Wickman .337
- The Principles of Alternating Currents, By Willard Doud .339

The Railroad Electricians' Club:
- Lead Storage Battery Questions .342
- Edison Storage Battery Questions .342

A. B. C. Car Lighting Course: Some Peculiarities About Battery Grounds .345

Practical Stunts .347

With the Manufacturers .348

Association Directory .352

STATEMENT OF THE OWNERSHIP AND MANAGEMENT

(Required by the Act of August 24, 1912.)

of the Railway Electrical Engineer, published monthly at Chicago, for April 1st, 1915.

Editor, C. D. Sperry.

Managing Editor, Edward Wray.

Publisher, Edward Wray.

Owners: (If a corporation, give its name and the names and addresses of stockholders holding 1 per cent or more of total amount of stock. If not a corporation, give names and addresses of individual owners.)

Edward Wray, Park Ridge, Ill.

Known bondholders, mortgagees, and other security holders, holding 1 per cent or more of total amount of bonds, mortgages, or other securities: (If there are none, so state.)

None.

EDWARD WRAY,
Publisher.

Sworn to and subscribed before me this 20th day of March, 1915.
(Seal) EDW. J. SCHUMACHER.

(My commission expires April 8, 1917.)

Under Frame Suspension of Car Lighting Generators

In the suspension of the axle car lighting generator, the practice in America has been radically different from that in Europe and elsewhere. In these countries the axle generator, for the most part, has been suspended from car body while on practically all American axle lighting equipments and on some foreign equipments the generator has been mounted directly upon the car truck. Moreover considerations of accessibility for inspection and repair have required that the generator be mounted outside the truck frame, and this has made it necessary to employ rather heavy suspension rods and braces; at the same time this weight of generator and suspension parts, aggregating over half a ton, has considerably unbalanced the truck. It is interesting to note that an American manufacturer of axle car lighting equipment now advocates the use of the body-hung type suspension and it would seem that there are many advantages to be gained by using this type of suspension which warrant its extensive use, provided it meets all the conditions of service encountered in this country.

The questions of generator belt clearance have always been serious problems for the designer of truck type suspensions and with the recent developments in steel car construction these difficulties have become more acute. It has been necessary to use a large generator pulley in order to secure proper belt clearances and this has required a generator correspondingly large for the slow speed operation.

This difficulty of securing proper belt clearance has undoubtedly contributed in a large measure to the high mortality rate among car lighting belts. It is a well proven fact that open-end type trucks, in which there are no obstructions to come in contact with the car lighting belt, have shown nearly double the average belt mileage of belts driving generators mounted on standard type trucks with end sill, brake rigging, etc.

Removing the generator from the truck and suspending it directly from the car body accomplishes several things; in the first place the unbalanced and unsprung weight of the generator is removed from the car truck; sufficient belt clearances are obtained so that a smaller generator pulley and high generator speeds may be employed; accordingly a considerable reduction in size and weight of the generator is effected.

By suspending the generator from the car body it is in most cases possible to obtain large clearances for the belt in passing both the brake beam and the end sill, so that it would seem that we might expect a longer belt life from this type of suspension on this account. With the swing of the truck in rounding curves, however, the generator is thrown out of alignment, and this may cause the belt to wear on the pulley flanges.

Few of us probably realize what severe service an axle lighting generator mounted on a car truck encounters, but the shocks, particularly, going over crossings, switches, and rough pieces of track are often excessive. With the generator mounted on the car body these shocks and blows are all absorbed by the car springs and accordingly the wear and tear on the generator parts with the body hung suspension should be considerably reduced.

It will be interesting to follow up the operation of this new type of equipment and we hope to be able to publish some service data on this subject in a short time.

Automatic Block Signal System for Shop Traveling Cranes

E. Wanamaker, Electrical Engineer, Rock Island Lines

Abstract:—A pair of signal contact rails with staggered joints is mounted on each side of the shop. Relays operated from 250 volt crane power are carried on each crane. The signal system operates on closed circuit principle and relay current flows through multiple contact signal shoe. An open circuit or poor contact on rails will ring signal bell. A wall crane coming into the same block as a bridge crane will show warning light signal, provided bridge crane trolley is in the center so crane can pass. If bridge trolley is at the side, the danger whistle signal will be automatically given.

In many railroad shops we find an installation of overhead bridge cranes with wall cranes beneath such as that installed at the Silvis shops of the Rock Island Lines; and where these cranes are operated without any automatic signaling device, as has been done in the past, there is a constant danger of a collision due to lack of clearance between one of the wall cranes and the cage or the load being carried by one of the bridge cranes.

To obviate this difficulty a complete system of automatic block signaling has been devised by the electrical engineering department of the Rock Island and installed in connection with the traveling cranes at the shops.

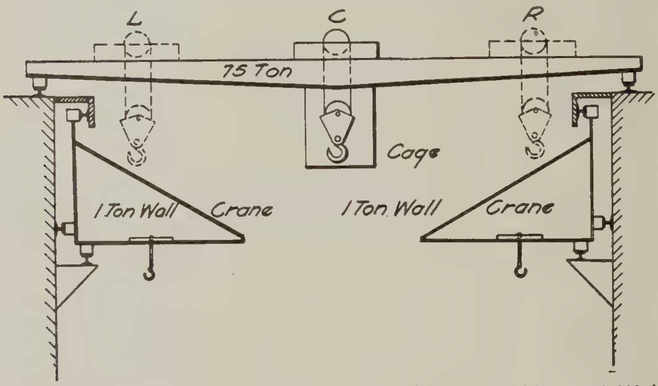


Fig. 1. Sketch Showing the Relative Position of Bridge and Wall Cranes.

In this shop there are two 75-ton bridge cranes of 95 ft. span which operate on the same track. A wall crane operates from a vertical track on each side of the shop and these run beneath the bridge cranes as shown in Fig. 1. This shop is laid out on the Herringbone plan, and the locomotives as they are shopped are first removed from the wheels by the bridge cranes, each crane lifting one end of the locomotive. The locomotive is then carried down the center of the shop to the proper pit, the tracks of which are set on the diagonal, and by careful manipulation of the two cranes the engine is swung around to proper position and lowered to its pit. The wall cranes which are of one ton capacity, each operate over one row of pits and serve for removing and replacing the locomotive parts. The wall cranes are high speed and the bridge cranes are low speed.

As shown in the diagram, Fig. 1, if the trolley of a 75-ton crane is at the center section, as shown by the full lines, either wall crane can safely pass under but if the trolley of the bridge crane is over near either side in the position "R" or "L" shown dotted, the wall crane which is on the same side of the shop as the trolley of the bridge crane, cannot pass.

Should the wall crane collide with the bridge crane or with the load suspended by it, the wall crane would be thrown from its track, thereby endangering the lives of its operator and the workmen beneath.

A successful automatic signaling system for such a shop crane installation must then fulfill the following conditions:

1. To give an unfailing danger signal when a wall crane approaches a bridge crane with its trolley over to the side on which the wall crane is operating.
2. To give a warning signal to both operators when a wall crane approaches a bridge crane which it can safely pass.

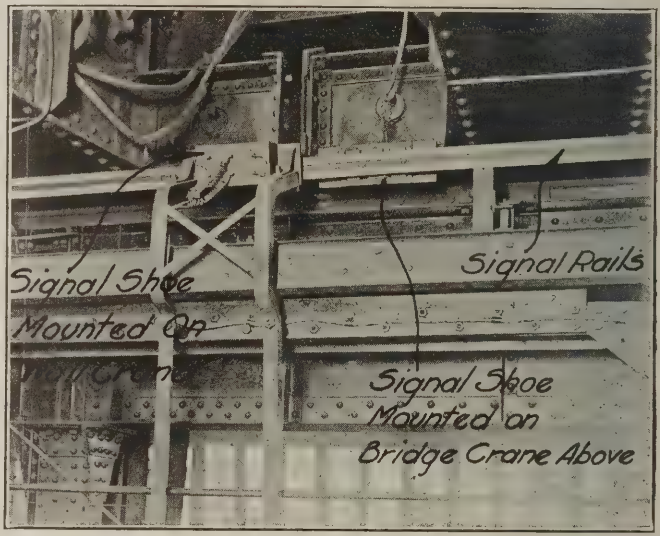

Signal Shoe Mounted On Wall Crane
Signal Rails
Signal Shoe Mounted on Bridge Crane Above

Fig. 2. Showing Signal Rails and Multiple Contact Signal Shoe on Both the Wall Crane and Bridge Crane Above. The Heavy Beams at the Top of the Illustration are the Main Girders of the Bridge Crane.

3. To not give a signal when the two bridge cranes approach each other as they work together on one engine, there being neither wall crane within a dangerous distance.
4. To not give a signal when the two wall cranes pass each other, there being neither bridge crane within a dangerous distance.
5. A suitable signal to be automatically given at any time the crane signal system is out of working order, regardless of the position of any of the cranes.

Method of Operation.

This crane signal system is operated on a closed circuit principle; i. e. the signaling circuit is always closed, no matter whether or not a danger signal is being given. The relays of the system operate on the principle of a change in current strength when resistances of proper values are thrown in series and parallel connections.

A block system of staggered contact signal rails is mounted just below the track of the bridge cranes, as shown in Figs. 2 and 3. This contact rail is made up of two steel channels bolted together with a slab of fiber insulation between. The edges of the channels are shown in Fig. 2 and the top of one channel in Fig. 3. These rails are 120 ft. long, staggered so as to have the joint of one rail come at the middle of the other. The maximum length of the signal block is then 120 ft. and the minimum is 60 ft.

Multiple Contact Signal Shoe.

Current of the signaling system must pass from the brush "C" to the contact rail above; thence to the brushes "A" and "B," thence through the wire connection to the brushes "A" or "B" and with one or both of these brushes in contact with the bottom rail, current is carried through the rail to the brush "D."

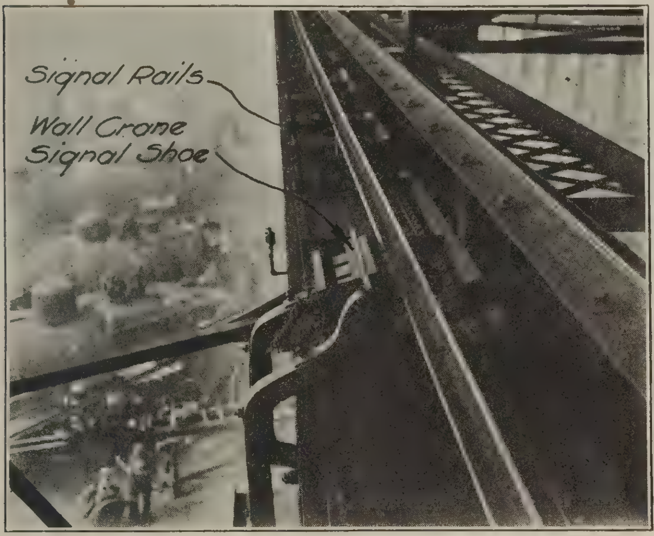


Fig. 3. View Taken from One End of Bridge Crane, Showing Signal Rails and Wall Crane Signal Shoe.

This current flow through the multiple contact shoe forms a part of the closed circuit signaling system so that if the contact shoe gets out of order, due to loose contact of the brushes or corroded rails, etc., an open circuit signal will at once be given. The 250 volt power circuit for the cranes supplies power for the closed circuit signaling system, so that any slight variation in contact resistance of this contact shoe will not cause any serious variation in the operation of the signal relays.

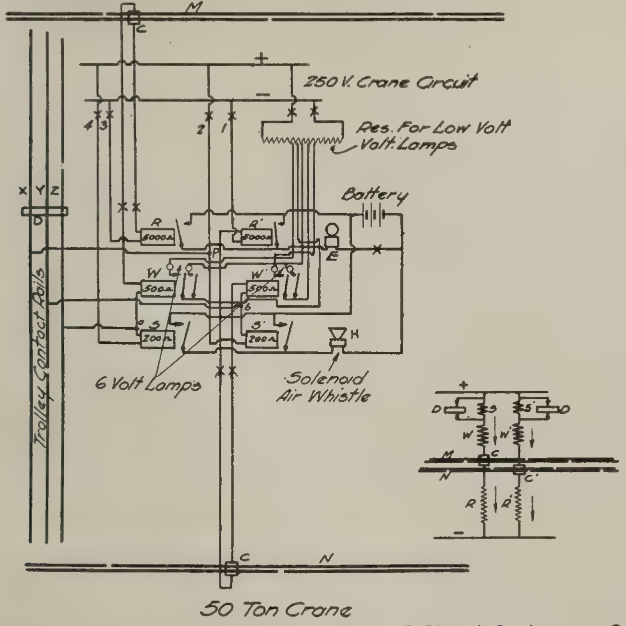


Fig. 4. Wiring Diagram of Connections of Signal System on One Bridge Crane Which is Isolated from All Other Cranes.

Explanation of Signal Circuits, Bridge Crane Isolated.

The diagram, Fig. 4, shows the connections of the automatic signaling system on a 75-ton bridge crane which is isolated from all other cranes. The staggered signal rails "M" are located on one side of the shop and the signal rails "N" are located on the other side of the shop. There are two distinct primary relay circuits. In one circuit current passes from the positive 250 volt crane bus, through line "2," to point "P," over to trolley contact rail "X," through short circuiting device "D" to the contact rail "Z"; from "Z" to point "A," thence through relay "W," contact shoe "C" on rails "M," relay "R," and line "3" to the negative 250 volt crane bus.

The other primary circuit passes from the positive 250 volt bus, through line "2" to point "P," over to "X," through "D" and "T" to point "B," through relay "W," contact shoe "C" on rails "N," relay "R," and line "1," to negative 250 volt bus. The relays "R" and "W" are now in series across the 250 volt line, and their resistances and adjustments are such that the current is sufficient to hold up the armature of "R," but not the armature of "W." Relay "S" is short-circuited by the shoe "D" on the trolley contact rails so that no current flows through the relay. If, however, the trolley contact device "D" (which is fastened to the crane trolley) is moved to one side (upwards on the figure) so that it no longer makes contact with rail "Z," the current will flow from the positive 250 volt bus through line "4," relay "S," relay "W," contact shoe "C," relay "R" to the negative 250 volt bus. But, the current now flowing through relay "S" is of such a value that the armature will not be attracted. The same explanation holds for the other circuit if the trolley contact "D" is at the other side of the shop (bottom of the figure) and fails to make contact with rail "Y," excepting that the current flows through line "2" instead of line "4."

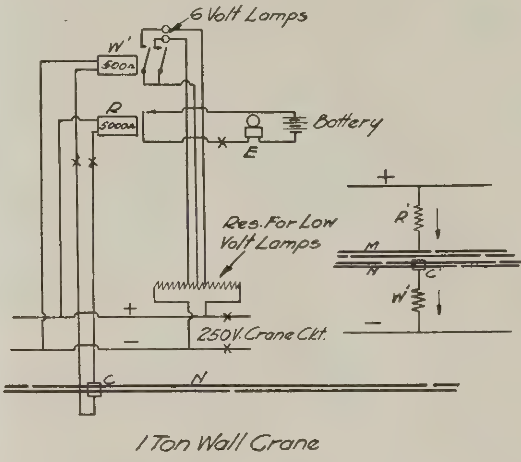


Fig. 5. Wiring Diagram of Signal System on a Wall Crane Which is Isolated from All Other Cranes.

The secondary cricuits of the relays "R" and "R_1" are open as long as the relay armatures are held up. The secondary circuits of relays "W," "W_1," "S" and "S_1" are open when the relay armatures are not held up. Therefore, as soon as the current fails to flow through "R" or "R_1," the secondary circuit is closed and the electric bell "E" will ring off the three cell battery "B." But, the secondary circuits of "W," "W_1," "S" and "S_1" will not be closed until the current in these relays is sufficiently increased, which takes place only when the cranes are in the danger position.

Connections with Wall Crane Isolated.

The diagram, Fig. 5, shows the electrical connections of the block signaling system when a wall crane is isolated from all other cranes. The current is now flowing from the positive 250 volt bus through the relay "R_1" through the contact shoe "C_1" and the relay "W_1" to the negative 250 volt bus. As in the previous case the relays "R_1" and "W_1" are in series across the 250-volt line. The relay "R_1" having about 10 times the number of turns that the relay "W_1" does, has sufficient magnetic strength to hold up its armature with this current of about .04 amperes flowing; while this current flowing through smaller coil "W_1" does not generate sufficient magnetism to raise its armature. Therefore both the secondary circuits of the wall crane will be open.

Bridge Crane and Wall Crane in the Same Block.

The wiring diagram, Fig. 6, shows the electrical connections of the bolck signaling system on both the bridge crane and the wall crane when both cranes are in the same block. The diagram shows the circuit for the wall frame which is on the opposite side from that shown in Fig. 5. The circuits on these cranes are the same as those just described in Figs. 4 and 5. It will be noticed upon referring to the simplified diagram in the lower left hand corner of Fig. 6 that while on the bridge crane the low resistance relays "S" and "W" connect directly to the positive bus, on the wall crane the low resistance relay "W" connects directly to the negative bus. The large six brush contact shoe "C" makes connection between the low resistance relay "W" and the high resistance relay "R." When the contact shoe "C" of the wall crane and the contact shoe "C" of the bridge crane come into the same block, the block signal rail "M" will then provide a direct path from the positive bus, through "D" or "S" and the low resistance relay "W" of the bridge crane and the relay "W" of the wall crane to the negative 250 volt bus.

The relay "R" of the wall crane is now thrown in parallel with the relay "W" of the 75 ton crane and the relay "W" of the wall crane is likewise connected in parallel with the relay "R" of the 75-ton crane. These two parallel circuits are connected in series by the block signal rails "M" and the whole connection of relays is then across the 250 volt buses. Or, stating the situation more simply, the contact shoe of the wall crane, making contact on the same block signal rail as the contact shoe of the 75-ton crane, will connect the two relays "R" in series across the 250-volt buses, and the two relays "W" are also connected in series across the 250 volt buses. Current in both relays "R" is now reduced to nearly half of what it was originally, but this current is still sufficient to hold up the armature of these relays and prevent the open circuit signal of the electric bell being given.

Since the two low resistance relays "W" are now connected in series directly across the 250-volt buses, the current through these relays will be greatly increased so that their armatures will now be attracted and their secondary circuits closed. It must be remembered that one relay "W" is mounted on the wall crane and the other relay "W" with its secondary circuits is mounted on the bridge crane so that when these relays operate they light the 6-volt signal lamps in front of the crane operator on both the bridge crane and the wall crane.

Signal Lights.

These signal lamps are located immediately in front of the crane operator as shown in Fig. 7, where they are sure to be seen by him. They are of the 6-volt type, giving about 10 candle power illumination and are protected by a metal guard, as shown. The current for lighting these signal lamps is taken direct from the 250 volt crane circuit by tapping off at the proper points on a resistance connected directly across the power buses of the crane.

The 6-volt lamps, with this method of obtaining the low voltage, was selected in preference to using two 110-volt lamps in series, because of the fact that these light signals are merely for warning the operators and a larger lamp was considered unnecessary. In fact, might become a source of trouble due to the glare of the high candle power lamps flashing frequently as the trains pass and would impair the efficiency of the crane operators.

Operation of the Danger Signal.

A powerful shrill whistle is mounted on each bridge crane to give a danger signal in case a wall crane

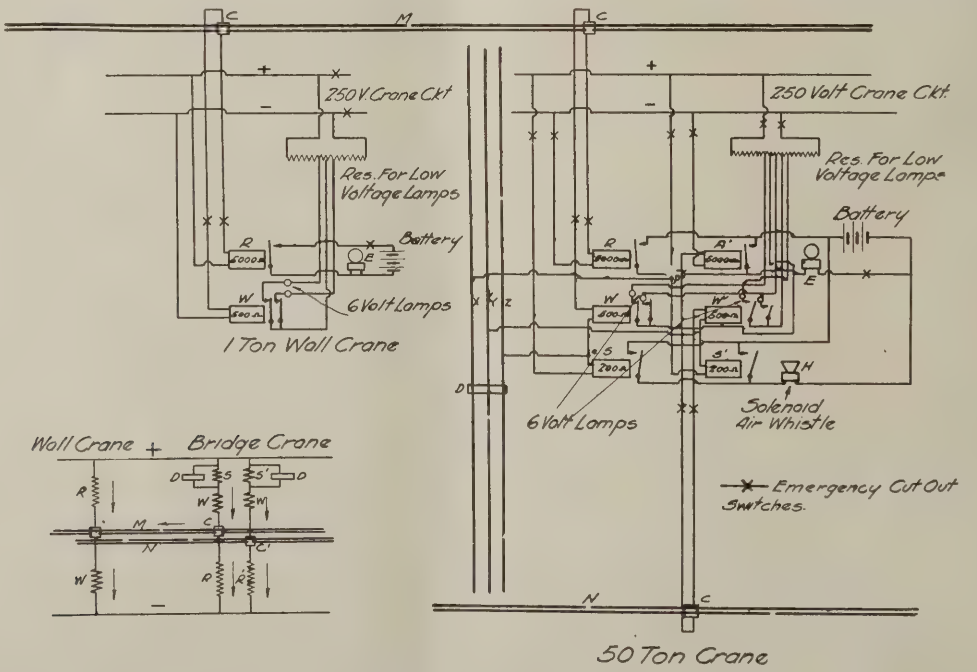


Fig. 6. Wiring Diagram of Signal System When a Wall Crane and a Bridge Crane Come Into the Same Block.

approaches or is approached by a bridge crane on which the load is not carried at the center so as to provide sufficient clearance to allow the wall crane to pass. If the trolley of the 75-ton crane is over at the side so that it might collide with the wall crane, should the latter attempt to pass, the short circuiting device "D" would fail to make contact with the rail "Z," thus allowing the increased current through the relays "W," when both cranes are in the same block, to also pass through the relay "S" on the bridge crane, causing the armature of this relay to be attracted and to close its secondary circuit. When this takes place the contact of the relay "S" will then permit current to flow from the primary battery through the solenoid "H" drawing up its plunger and operating the air whistle. The solenoid "H," with its air valve connection to the whistle, is clearly shown in Fig. 8.

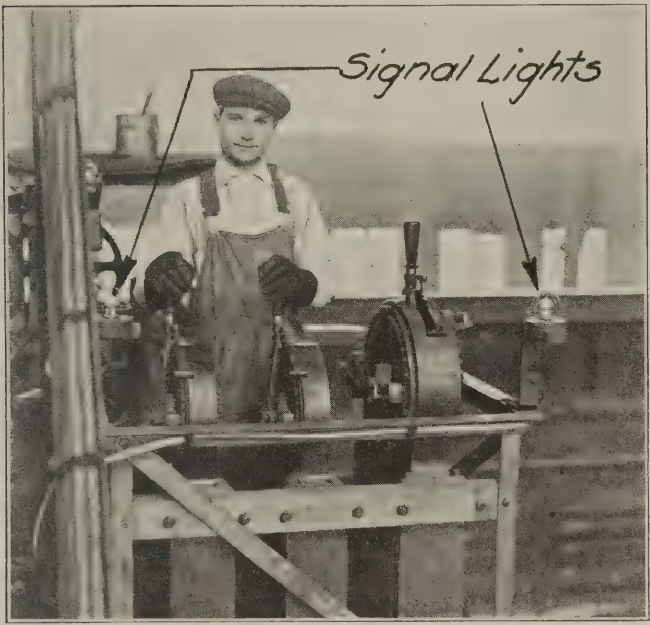


Fig. 7. Crane Controllers Showing Position of Signal Lights.

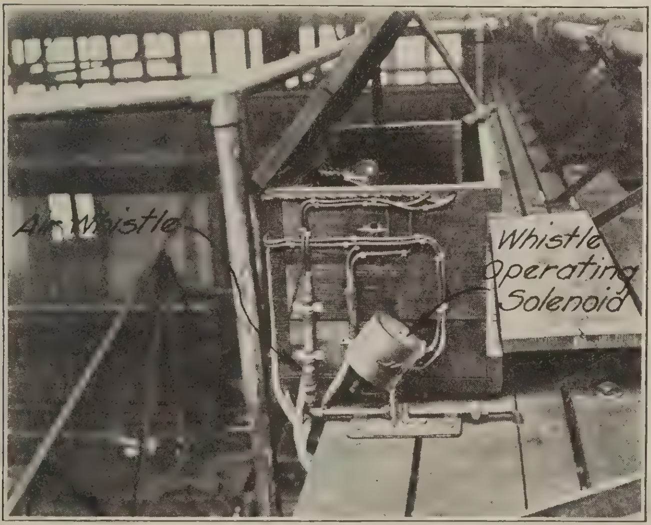


Fig. 8. Apparatus Box Mounted on Bridge Crane Which Contains All Relays Shown in Fig. 5. Air Whistle Danger Signal and Operating Solenoid Are Mounted on the End of the Box as Shown.

If the other wall crane also approaches the 75-ton bridge crane the relays "R_1," "W_1," and "S_1" would be operated, provided the bridge trolley was over at that side of the shop far enough to interfere with passing the wall crane. Both light and whistle signals would then be given; but if the wall crane was able to pass, only the light warning signals would be shown. It should be noted that either the solenoid "S" or "S_1" will operate the solenoid air whistle, the same whistle on each bridge crane serving for both wall cranes. An air tank of 22 cu. ft. capacity at 120 lbs. pressure is carried on the bridge crane and this contains a sufficient volume of air for about a month's operation. An air charging line is installed at one end of the shop so that if the pressure in the air tank gets low the crane can quickly charge its air tank at the noon hour or at any other convenient time.

Summary.

It will thus be seen that the relays all carry some current (with the exception of the relays "S" and "S_1," which are short circuited by the brush "D") and these relays are operated by a change in the current.

The relays are so connected that these changes of current from the various relays are great enough to give the proper signals at the proper time regardless of the position of, or the number of cranes in the same block. Credit should be given to Messrs. L. F. Hatz and J. Edwards of the electrical department of the Rock Island who assisted in the design of this system.

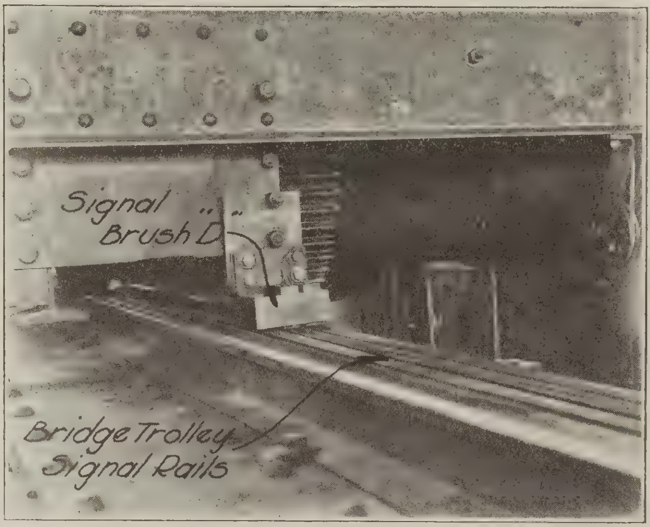


Fig. 9. Bridge Trolley Signal Rails, "X-Y-Z," Which Control the Operation of the Danger Signal. If the Trolley is in the Center of the Crane, Contact on These Rails Will Prevent the Danger Signal Being Given, as the Wall Cranes Can Now Pass Safely.

Leakage Currents from Electric Railways.

In a paper before the Institute of Electrical Engineers, Mr. H. E. Yerbury discussed the effect of leakage currents from the grounded return of electric railways. He pointed out that where the rails are postive to the pipes in the vicinity of the tracks there is no detrimental action to the pipes, but when the pipes are positive to the rails corrosion occurs.

In conclusion, the paper states that corrosion is more often due to local electrolytic action. This may be started by a speck of rust, which forms with the iron a galvanic couple, the oxide being electro-negative to iron. The electrolyte might be formed by the presence of some weak acid. This miniature galvanic cell is then operating in a closed circuit, and the growth will continue until considerable damage has been done. This action could be partially prevented by dipping the pipe in some bitumastic solution that would form a tough adhering covering.

Operating Results of Steam Railroad Electrification

The meeting of the Western Society of Engineers, held on the evening of March 16, 1915, was given over to the discussion of steam railroad electrification, the topic of the evening being "Operating Results of the Electrification of Steam Railroads." This subject was chosen with special reference to the Convention of the American Railway Engineering Association, which was being held in Chicago at this time. The topics of the papers and discussion were confined to things of interest to the steam railway engineering operating officers. A large number of the members of the A. R. E. A. were present and the rooms were crowded to their capacity. This was one of the most comprehensive discussions of electrification that has been held, advocates of all the different systems which are prevalent in this country being represented.

Edwin B. Katte, chief engineer of electric traction of the New York Central, spoke on the results secured by this road. W. S. Murray, consulting engineer of the N. Y., N. H. & Hartford R. R., described the progress made on his road. George H. Gibbs, consulting engineer of the Norfolk & Western and Pennsylvania System, told of the development on those two roads.

St. Paul Electrification.

Mr. C. A. Goodnow, assistant to the president, C. M. & St. P. R. R., prepared an interesting paper on the results which are anticipated from the electrification of an entire engine division on the St. Paul R. R. between Harlowton, Mont., and Avery, Idaho. This was described at length in the January number of the Railway Electrical Engineer, so will not be discussed at this time. As this is the first time an entire engine division has been electrified, so operating results will be watched with a great deal of interest.

Results on N. Y. Central

Edwin B. Katte,

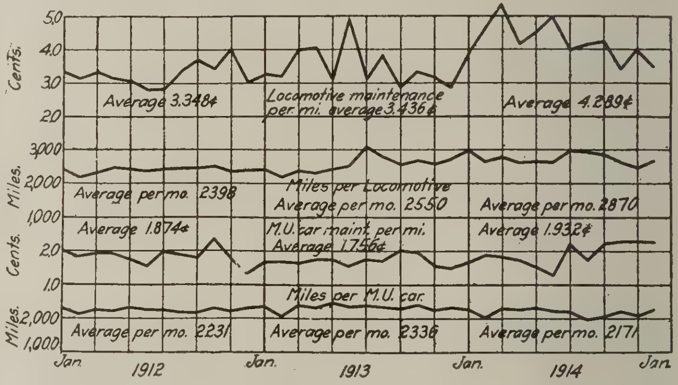
Chief Engineer Electric Traction, New York Central Lines.

The most interesting thing about electrification to railroad men at the present time is the first cost, and here the comparison with steam operation is most unfavorable. For example, a modern steam locomotive costs about $25,000, and an electric locomotive of the same capacity costs, say, $45,000. That is not all. The cost of the power station, transmission lines, substations and working conductors must be added, which will bring the equivalent cost up to about $110,00, more or less, depending upon the system adopted and the character of the service. Hence, there should be a large saving in operating costs to cover the increased fixed charges, or there must be some other good reason for incurring the additional expense.

The New York Central electrified its lines into Grand Central Terminal because it had a bad four-track tunnel condition to deal with at the most congested point of traffic. After electrification was decided upon, a very comprehensive scheme of improvements followed, which has cost in all something like $120,000,000, resulting in radical changes in the movement and operation of trains. It is for this reason that a direct comparison between the former steam and the present electric operation is impossible. However, some general comparisons can be made, based upon rather broad assumptions.

The average cost per locomotive mile, derived from a large number of records of steam locomotives in all classes of service, has been found to be about 26 cents, including fuel and supplies, maintenance, repairs and engine house expenses. A similar figure for electric locomotives operating in and about New York City can be shown to be about 21 cents, but when fixed charges are added the comparison becomes 30 cents for steam locomotives and about 60 cents per mile for electric locomotives. This comparison is only approximate and open to criticism, because of the fact that conditions in New York permit but an average of 85 miles per day for electric locomotives, while the steam locomotives are averaging about 150 miles per day. Further, many assumptions, too numerous to describe in this brief discussion, were necessarily made which would preclude the acceptance of these figures as a direct comparison of facts, but are sufficiently accurate to indicate the tendency.

The electric locomotive service in New York and vicinity includes switching in yards and terminals, hauling shop trains about six miles, and a main line express service on one division of 34 miles and another division of 24 miles. The average cost for maintenance, including inspection, repairs, renewals, cleaning and painting, varies from month to month, but the average, covering a period of eight years, is not far from 3½ cents per mile. The maintenance during the past year has been about 4⅓ cents per mile. The increase was caused by the renewal in one year of driving wheel tires on the first 35 locomotives purchased.



Operating and Maintenance Cost of Electric Locomotives and Multiple Unit Cars, and Average Monthly Mileage Per Locomotive and Per Multiple Unit Car.

The suburban service in the vicinity of New York City is handled by multiple unit trains, consisting of from two to eleven cars, with trailers used in the proportion of two motor cars to one trailer on trains having easy schedules. Maintenance, including mechanical and electrical repairs, inspection, renewals painting, etc., excluding only sweeping and window cleaning, has averaged somewhat less than 2 cents per car-mile.

The working conductor used by the New York Central is a special type of underrunning third rail, and is believed to afford greater protection from accidental contact than any other third rail. Its chief characteristics are, first, a wooden sheath enclosing the live third rail, except at the bottom or contact surface, and second, an insulated support, so hung as to afford flexibility to prevent strains due to the up and down movement of the supporting ties under traffic. The cost of maintaining this protected third rail is naturally higher than for the usual type of third rail, and the large amount of construction work in progress adjacent to the third rail has increased the maintenance cost above normal conditions. The average cost has been about $26 per mile, per month, on the main line and $40 for yards and terminals including track bonding and cable connections, both positive and negative.

The cost of maintaining the New York Central Railroad's cable system can be of little comparative value, because of the great diversity of its character to meet unusual local conditions. Lead-covered, paper-insulated cables are used in underground tile ducts. Steel-wrapped, varnished-cambric cables are used in iron pipes on the Park Avenue viaduct; armored, lead-covered, rubber-insulated cables are laid under the Harlem river, while bare copper, aerial cables, supported on steel poles, are used in the outlying and less congested districts. However, as a general statement, it may be said that the cost of maintaining the three-phase A. C. lines is about $8 per circuit mile per month, and the direct current cables cost about $13 per cable mile.

The cost of electric current varies considerably with the prices paid for coal, which in New York average from $2.50 to $3 per short ton. Also the fact should be noted that power stations in the vicinity of New York City are operated on three 8-hour shifts in place of the more common 12-hour shifts. Eleven thousand volt, three-phase, 25-cycle current measured at the busbars of the Port Morris power station averages between 0.45 of a cent and 0.50 per cent kilowatt hour for operating labor and materials. When fixed charges are added, the cost averages about 0.75 cents. The transmission of current to the substations, transforming in sub-stations, the loss in the working conductor system, and adding all fixed charges will bring the average total cost of current delivered to the shoes of equipment, to about 1.75 cents per kilowatt hour.

As a measure of the reliability of electric equipment, a comparison of the locomotive or car miles per detention is preferable to a detention of the miles per minute detention, since the former excludes delays to following trains and other causes of delay in no way contributed to by the equipment. During the year 1914 the average locomotive miles per detention was 22,000, while the multiple-unit cars averaged 51,000 miles per detention. The train-minute delays due to electric power troubles totaled 840 minutes for the year. The aerial lines contributed most largely, namely, 535 train-minutes; the third rail caused 244 minutes' delay, substations 25 minutes, and the power stations have never caused a minute's delay during their eight years of operation.

The electric locomotives used by the New York Central in express passenger service have a speed of 60 miles per hour when drawing a 1,200-ton train. All axles are equipped with motors, each having a continuous capacity of 250 hp., or 330 hp. on the one-hour rating, that is, 2,640 hp. total. The locomotive is equipped with an oil-fired, flash type boiler having a capacity of 2,000 lb. of water per hour for heating through trains. The complete weight of the locomotive is 132 tons, all of which is carried on the drivers, thus giving a drawbar pull of 66,000 lb., assuming 25 per cent adhesion. The multiple-unit cars are of all-steel construction, 60 ft. long over buffers and weigh about 57 tons. They seat 64 passengers each. There is one motor truck under each motor car, having two motors of 200 hp. each. The maximum speed of the train is 54 miles per hour.

Advance of Electrification

W. S. Murray,

Consulting Engineer, New York, New Haven & Hartford.

We are rapidly putting far behind us the days when the attitude of railroads was to sit by and watch some one or two other railroads experiment with electricity as a motive power. Indifferent interest has given way to the realization that these pioneer roads who have been using this new power in every form of railroad movement have developed a fund of data which entitles electrification to more than passing interest, and requires that the other roads be keenly alive to the possibilities it may hold out in the matter of betterments to their own property.

That a thing of any character has the right to live and improve is based entirely on whether it is founded on correct principles. In the early days, when electrical movement was first introduced on heavy traction railroads, theory was strong and practice severely limited. The guiding principle upon which electrical men based their opinions that electrification had its proper place in the economic world was that by its use certain savings could be effected that would justify the investment necessary to secure it. There was entirely outside of this, but indirectly an economic factor, the advantage accruing to the passenger in the form of a clean ride.

While I have, of course, been keenly interested in electrification that has been applied to other railroads, naturally the past 10 years' association with the New Haven work, during which time over $15,000,000 have been expended in this department of betterment, has brought the real elements of its progress within very close range.

In June, 1914, the first New York, New Haven & Hartford passenger train was operated from Grand Central Station to New Haven over a four-track electrified route of 73 miles in length. Between New York and New Haven, measured upon a single track basis, there are some 500 miles of electrified line, of which 184 are included in yards and sidings. On these tracks today, every class of passenger, freight and switching movement is made, and electrical statistics are kept of all power house, line or equipment failures, a reference to them suggesting the features of electrical operation that requires first attention for the betterment of service.

Mr. Murray then told of the method to check power consumption on the various trains. We have already described this at some length in the RAILWAY ELECTRICAL ENGINEER, August, 1914.

While our present freight movement by electricity on the main line is today limited both on account of the general depression in business, together with the fact that a full complement of electric freight locomotives is not yet at hand, there is no question in my mind but that the greatest returns to be secured by electrification will be through freight movement. While in the past we have appreciated the economies to be secured through electrification, by virtue of the lesser expenditures required in fuel and maintenance of electric engines as against steam, there is fast coming to the front what might be called a more visualized economy in the reduction of expenses by effective savings in train miles.

Keeping Tab on the K. W. Hours.

Illustrative of the economic value of a "kilowatt hour" in its application to an electrification system. I quote from a part of a recent letter which had reference to the utilization of some 4500 k. w. of demand in connection with its application to the eastern section of our electrification zone. I would particularly draw your attention to the item of $49,275, which has reference to the economies to be gained by the double heading of freight trains operated between Harlem River and New Haven. This economy, and its automatic complement, the increase of track capacity, are the phases of electrification that are striking deep into the consideration of the steam operating railroad man.

"(1) The extension of the station contemplates, as you know, supplying a maximum single-phase demand of approximately 4500 k. w. This amount of power, measured by train units, would permit the operation of 12 additional daily trains in fast freight service of average tonnage or its equivalent in any other class of service between Harlem River and New Haven.

"(2) The number of kilowatt hours which would be consumed by the above trains would be 17,500 k. w. h. annually, and, upon a coal ratio of 1 to 2 in electric and steam service and a basis of 3 lb. per kilowatt hour and $3 per ton, an annual saving to the railroad company of $78,750 is indicated.

"(3) Further translating the above movement into engine miles, our log sheet records indicate that the number of engine miles required for the above movement would be 990, which, multiplied by the difference in cost of engine repairs at five cents per engine mile, effects an annual saving of $18,250.

"(4) The transfer of 12 daily trains from steam to electric service will permit a further extension of our present practice of 'double heading' trains in electric service, thus saving 450 daily train miles, which, as shown by our log sheet, will secure an annual reduction in train wages of 30 cents per train mile, corresponding to an annual reduction of $49,275.

"(5) A supply of approximately 3,000 k. w. (average) to the New Haven end of the line will effect a further saving of $16,500 in transmission losses, as compared with the transmission losses of the same amount of power from Cos Cob Station, the above savings being based upon the conservative cost of 5 miles per k. w. h. In explanation of the apparently large value of the saving in transmission losses to be effected by this small installation, it will be evident that its value is a maximum when applied at the extreme end of the transmission system.

"(6) No tangible values can be assigned for the very important effect upon the regulation in line voltage at New Haven, which will be reflected in the cost and efficiency of operation in many ways.

"(7) The summary of the total savings as above which will be effected is as follows:

Fuel	$78,750
Engine repairs	18,250
Engine and train wages	49,275
Transmission losses	16.500
	$162,775"

Freight Trains Run at Greater Speed.

If any criticism can be placed with regard to the matter of freight movement by electricity, I would say it would be in the matter of speed. The electric freight locomotives of the New York, New Haven & Hartford were built on specifications that permitted them to operate 1,500-ton trains on level track at 35 miles per hour. While the speed element, in as far as the New Haven service is concerned, may be entirely justified, due to the very large ratio of passenger to its total service, thus permitting the freight trains to clear promptly for passenger traffic, I would say that where the ratio of passenger service is less, the speed element for equal horsepower could be more valuably thrown into traction. For example, the New Haven locomotives have drawbar pull characteristics that permit the operation of 3,000-ton trains by double-heading. If these engines were reduced in speed by 35 per cent and their traction increased by the same percentage, 4,000 tons would be the resulting double-header trailing load, which in turn would effect a large saving in train miles, were these engines to be operated on a property less subject to passenger movement.

Much valuable information has been developed in the past two years in connection with the handling of classification and switching yards by electric motive power. An idea as to the reliability of this class of service may be gained in saying that in 1,000,000 electric switch engine miles there has been but one failure. The New Haven property includes in it two large switching yards; the Oak Point yard, containing 35 miles of track, and the Harlem River yard, 25 miles. The introduction of the electric engine in these yards has increased the speed of the yards very greatly, and, as nearly as I can gather from the yardmasters, this increase of speed has been secured with a ratio of electric engines to steam engines replaced varying between 4 to 6 and 6 to 10.

Electricity in trunk line territory is now on a plane of consideration entirely different from the earlier days, when it was new, untried, and problematical. The future will see its agency playing a most important part in railroad competition.

Single Phase Favored.

It would seem very inappropriate, with so good an opportunity as this, not to say a word or two as to "system." I am frankly willing to admit that I am a firm believer in the single-phase system for trunk lines, the governing element in which, from an electrical standpoint, has been the transmission system. In a rigorous determination to adhere to this principle as correct for such a field it has not been to gainsay the application of direct current in the territory where it rightly belongs, namely, where the governing element has been (mass trains under acceleration and braking in close headway) in translation. As a citation of the two examples, I would offer: (1) The electrification from New York to New Haven, and (2) the electrification of the New York subways.

In closing my address I would speak of two things which to my mind are most pertinent to the advance and successful utilization of electricity in the field of heavy traction. The first is with reference to the mercury arc rectifier, and the second is in regard to the effect of electrical administration on the railroads electrifying.

With reference to the mercury arc rectifier, I feel sure that it will be of interest to state that a car has been in commercial operation on the New Haven road taking power from the 11,000-volt overhead contact system, and converting it into direct current for application to its propulsion motors. This car has been giving a most successful service, and the problem of the production and maintenance of the vacuum tube, through the agency of which the alternating current is converted into direct current, has been electrically and commercially solved. What are the possibilities accruing from such a result? This can be epitomized in the statement that if the economies in the transmission system of the single-phase justified the utilization of a heavier and less efficient motive power, today we are in a position not only to secure the economies gained in this transmission, but operate beneath the contact wires of such a system the more efficient and lighter direct current apparatus. As a concrete and practical application of this result, the present alternating current motive power now in use on the New Haven will be increased 25 per cent, by the application of the rectifier, and will also permit it to enjoy simultaneously transmission and motive power facilities of the highest order of efficiency.

For further information on this electrification see the Railway Electrical Engineer, Feb. 1915.

N. & W. and Penn. Electrifications

George Gibbs,
Consulting Engineer, Norfolk & Western and Pennsylvania.

The Norfolk & Western is an important trunk line with a large and diversified business. Especially important is its growing business in coal, both east and westbound. Eastbound from the summit of the Allegheny Mountains to tidewater, a distance of 375 miles, is the part of the road that we are especially interested in in connection with electrical equipment. The grade selected for electric traction is known as the Elkhorn grade in the Pocahontas coal region. The tonnage on the road is very heavy, and has doubled during the past four years. It amounts now to an average of 40,000 tons a day and has exceeded 60,000 tons. This produces a favorable condition for electric traction, as density of traffic has an important bearing on economies.

Another important consideration in the decision to electrify is the fact that the section selected is a gathering division, starting at Bluefield west of the Allegheny summit and includes about 30 miles of heavy grade along the western slope, including practically the entire gathering division for that particular Pocahontas field. This means that the division now is operated as a switching and gathering division by segregated class of power. Starting from Vivian eastbound, there are about 5.5 miles of one per cent grade. Then another 5.5 miles of 1.5 per cent grade, and then about 4 miles of 2 per cent grade, to the Elkhorn tunnel. Beyond the tunnel one descends a 2.5 per cent grade for about a mile and then encounters a 0.4 per cent ascending grade for about 9.5 miles. Finally there are 4 miles of 1.3 per cent grade into Bluefield where the Classification yard is located.

The trains over these grades are hauled by Mallet engines, three engines being required to haul the train at a speed of 7 or 8 miles an hour over the division. In the Elkhorn tunnel this speed is reduced to about 6 miles per hour.

The tunnel is of limited cross-section and difficulties with smoke have, therefore, been intensified. The tunnel has been equipped with Mr. Churchill's method of ventilation, which consists of an annular nozzle through which air is blown into the portal of the tunnel at a speed slightly greater than the speed of the train—7 miles an hour for a train running 6 miles an hour. Naturally, the fact that the tunnel is on a heavy grade and the space limited, and that it is a single track tunnel, makes it the neck of the bottle for the entire movement.

Line Very Crooked.

That line is a very crooked one, about 60 per cent of the entire division being curved with maximum curves running up to 12 degrees on the main line, and 16 degrees on the sidings. While the weight of the trains is 3,250 tons now with Mallet service, the weight is cut down in winter time to as low as 2,900 tons in order to get the trains over the division.

A decision was arrived at about two years ago to electrify, and the matter was put in the hands of myself and partner as consulting engineers of the company to carry it out. It was apparent, in going over the line, which goes through a narrow valley, that it would be impossible to use a third-rail system, and that it was necessary to use some overhead system. That narrowed the problem to a consideration of the high voltage direct current and the high voltage single-phase system. A further analysis of the cost and other advantages of the latter system, That was of especial importance on account of the enormous power which we were required to apply to each train, meaning that the amount of current to be collected would be great at low voltage, and therefore that it was desirable to keep it down as low as possible by adopting the highest possible voltage.

Locomotives of Novel Design.

In adopting this system a number of novel features were introduced especially in the type of locomotive. We bring the single-phase power to the locomotive, convert it into three-phase power and use it in three-phase motors. By this arrangement we obtained the advantage of a single overhead conductor, which advantage is great in complicated yards and on crooked lines. The three-phase motor is not adapted to other classes of railway service. It is essentially a one or two-speed motor. It is not suitable for main line service requiring very little speed, but it is eminently suitable for tonnage work on heavy grades, as it is a rugged type of electric motor. Without commutator and having characteristics we have not been able to obtain in direct single-phase motors.

When I say that it has one or two speeds, I mean that the speed of the train will be maintained, irrespective of the load and the grade at any speed at which the motors are set. If on going down grade the speed is exceeded by coasting, the train pushing the locomotive, the motors automatically return the current to the line at normal voltage and may be used in propelling trains up grade if there are any trains to propel. If there should be none the power is absorbed in a special rheostat.

For this service we had built and provided 12 locomotives, besides having three-phase motors that have some novel mechanical characteristics. Each locomotive is equipped with eight three-phase motors, arranged with four 8 and 4 pole combinations, to produce 14 and 28 miles per hour, respectively. The total length of the locomotive is 105 ft. over all and the diameter of the driving wheels 62 in. The Norfolk & Western locomotives weigh a total of 270 tons apiece, with 220 tons on the drivers. The drawbar-pull varies from 114,000 lbs. during acceleration at the 14-mile per hour speed, to 86,000 lbs. when operating at this speed uniformly on a one per cent grade, but on a recent test a locomotive developed a tractive effort in excess of 170,000 lbs., indicating, however, a coefficient of adhesion which cannot be assumed in practice. The maximum guaranteed accelerating tractive effort for a locomotive is 133,000 lbs. At the present time about half of this section of the road, including the entire heavy grade division, has been operating for about a month, and the experience we have thus far encountered indicates that our anticipations are to be realized in obtaining a remarkably successful installation. The trains accelerate promptly and without jerking on the heavy grades. On the 0.4 per cent grades we obtain a speed of 32 miles per hour with a 5,200-ton train behind the engine. On a 2.5 per cent down grade we are able to hold the trains at a speed not to exceed 14 miles an hour. As soon as the speed exceeds the 14-mile limit the current drops to zero, then mounts up in the opposite direction, and we return automatically to the line an amount of current probably in excess of 2,000 kw.

The acceleration of these heavy trains, as regards the amount of power required, is impressive. Our preliminary tests indicate a development of 11,000 hp. on one train during the acceleration period, and 8,000 hp. when running at uniform speed. I believe these figures are in excess of any amount of power delivered on steam locomotive trains anywhere in the world.

Discussion.

A great deal of interest was shown in the papers and pictures of actual installations proved most instructive. Motion pictures were shown of the B. A. & P. electrification. The discussion which took place at the conclusion of the papers cleared up many points that had not been covered fully in the papers.

Charles S. Churchill, assistant to the president of the N. & W. R. R. discussed some of the conditions which will warrant electrifying. The chief determinations are whether business will warrant expense or not as economy is the result sought after. The N. & W. started their investigation as to the possibilities of electrification in 1905. At first it seemed that conditions were not yet favorable for electrification but it was ultimately shown that the saving in fuel and the resulting increase in carrying capacity would warrant electrification.

An accurate log was kept of all repairs and other costs on the 30-mile district under consideration. The delays and causes were also recorded. This record showed that considerable time was lost by steam locomotive stops in the long 2 per cent grades. Steam locomotives in this service made but one trip a day. The electric locomotives, due to a higher operating speed, can make two or three trips a day, so 11 electric locomotives are at present replacing 33 heavy duty steam locomotives.

Density of traffic is generally the factor that measures the economies to be gained by electrification. It probably would not pay a road to change to electric operation if its traffic density was less than 60,000 tons a day.

J. C. Mock, electrical engineer of the Detroit River Tunnel, told of what influenced the Michigan Central in this project. The success of the B. & O. and the Grand Trunk terminal electrifications were very instrumental. The grades that were met with were 2 per cent in one direction, and 1½ per cent in the other. About 1,500 cars a day were handled through this tunnel aggregating about 50,000 tons.

E. W. Herr, first vice-president, Westinghouse Elec. Mfg. Co., pointed out that we are only in the beginning of a period of electrification. Most of the progress to date has been in the last ten years. It is necessary to go slow in electric development for where electric machinery is installed where it ought not to be, it reacts against the manufacturer. Before any extensive electrifications are planned it will be well to wait a few years to see if existing installations develop any defects.

B. J. Arnold, member of the Railway Terminals Commission, showed that the steam railway men have not been idle. The modern compound engine with a steam superheater is a very efficient machine and will not be readily forced out of service due to economic considerations.

Among others that spoke were E. H. Lee, vice-president and chief engineer of the Chicago & West. Ind., pointed out that density of traffic would finally demand electrification. Judge J. Holdom and W. F. M. Goss of the Committee on Smoke Abatement and Electrification of Railway Terminals told of the work and findings of this committee.

Electrification of the Swiss State Railways.

It has been decided to electrify 1,880 miles of the Swiss State Railways, and, according to "Engineering," a commencement will be made with the electrification of the Gothard line. The section of line between Erstfeld-Bellinzona, 68 miles in length, which includes the Gothard tunnel, will be started first. The two power stations for this section, which are in course of construction, are situated at Amsteg, on the northern slope of the Gothard, and at Piotta. The Amsteg power station will have a capacity of 32,000 h. p., drawing its power from the Reuss, the head being 902 ft., while the Piotta power plant will use water under a head of 2,624 ft., and develop 50,000 h. p. The average power required in 1918 is expected to be 6,550 h. p. with a maximum of 19,000 h. p. On certain occasions, as in very cold winters, it is expected that only 6,000 h. p. will be available at Amsteg and 8,000 h. p. at Piotta, but arrangements will be made to ensure a constant output of 26,000 h. p. The electrical energy will be transmitted single phase at 60,000 volts to three, and eventually six, substations, where it will be reduced to 15,000 or 7,000 volts. The 7,000 volt pressure will be adopted during the transition stage when the line is worked partly by steam and partly by electricity. The through trains will consist of 10 four-axle carriages, and the locomotives are designed for a speed of 56 miles per hour. A lighter type of locomotive will also be built. The total cost of the Erstfeld-Bellinzona section is estimated at $7,490,000.

Norwegian Electrification.

The electrification of the railway between Kiruna and the Riksgrausen Station on the Norwegian frontier, mentioned in the RAILWAY ELECTRICAL ENGINEER Oct., 1914, has now been completed, and traffic was opened on January 19th. Loaded trains of 40 wagons are run at a speed of 37 miles per hour; previously the highest speed allowed was only 17 miles per hour. The work has been successfully carried out, although accompanied by some mishaps, among which may be mentioned that the telegraph line from Sweden to Narvik has been put out of service altogether, due to induction effects. Steps have now been taken to lay a double telegraph line. The telephone line is a double line supplied with discharging poles and transformers, and the induction on this is very small.

Prof. Pleyl and Engineer Holmgreen, of Stockholm, have now solved the problem in regard to induction as far as the telegraph line is concerned.

Shop Motor Section

Three-Phase Windings for Alternating Current Machinery

J. H. Wickman

The stator windings of a three-phase induction motor might serve for a number of alternating current machines. If the rotor of such an induction motor were removed and replaced by a rotating field with a number of poles corresponding to the stator winding and if the fields were excited with direct current and driven by some external force, three-phase power could be taken from the stator windings. This same machine would serve as a synchronous motor if the stator windings were connected to a three-phase source of energy at the voltage for which the windings were designed and if the rotating fields were supplied with direct current.

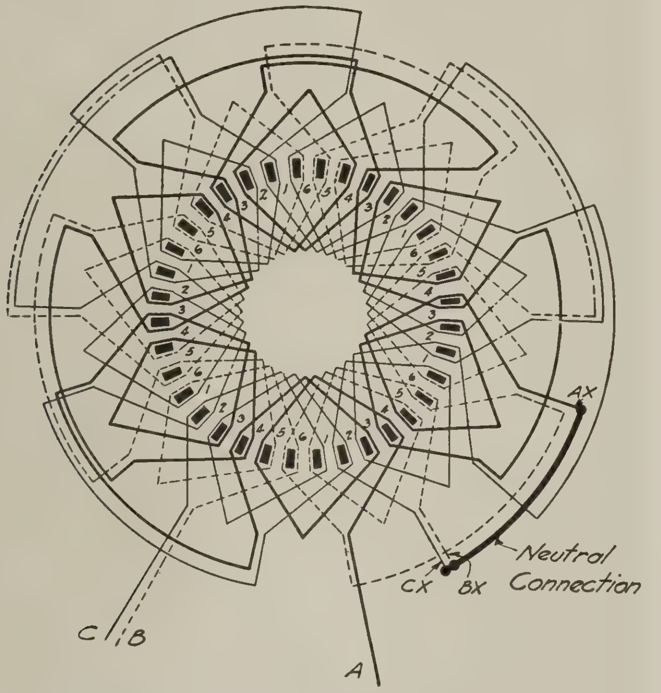


Fig. 5. Diagrammatic Representation of a Three Phase Six Pole Star Connected Winding.

So it may be seen that a knowledge of the winding of one of these machines is applicable to the others. All of these windings may be grouped under the general class of three-phase alternating current windings. The number of slots in the stator, the number of coils, the size of the conductors and the number of conductors per slot, are all determined by the design and depend on the speed, power and voltage of the machine. In general, the higher the voltage, the larger the number of coils and conductors placed in series with a corresponding increase in the amount and quality of the insulation.

As was brought out in last month's article on alternating current windings, the methods of connecting the conductors in the different slots are numerous. In that lesson several simple forms of winding were described and these methods as applied to three-phase will be extended upon in this lesson. Coils are generally wound on wood forms so that they will fit the stator slots. This method has the advantage of being more economical in that a large number of coils of the same size can be made at once and each coil can be tested, taped and impregnated with insulating paint or varnish before it is placed in the machine. The throw or pitch of a coil has been defined as the number of slots that are bridged by it. That is, if one side of a coil is placed in slot No. 1, the other in slot No. 14, it is said to have a throw of 1 to 14. Generally the throw of a coil is such that it connects conductors similarly located under adjacent poles, that is, the number of slots bridged by one coil is generally equal to the total number of coils under one pole and may be 1, 2, or 3 times the number of phases. For example, suppose a stator having 36 slots is to be wound for three-phase and is to be a 6 pole machine, the number of coils per group will then be equal to 36 divided by (6 times 3), which is equal to 2. This means that there will be two slots per phase in each pole.

The end connections are quite complicated in a three-phase motor. Such a winding is, however, nothing more than 3 single phase windings placed 120 electrical degrees apart and connected together either in delta or star. In some types of motors there is but one coil per slot, but most machines have two, that is, one side of two different coils laid in the same slot.

Fig. 5 represents a three-phase, six pole machine connected in a series star, that is the groups in each phase are connected in series and the phases are star connected. The neutral point of the star is represented by the heavy line Ax, Bx, Cx and A, B, and C are the line terminals through which the energy is supplied to run the motor. Slots No. 1 to 6 constitute one pole and similarly numbered slots occupy similar positions on the pole; this means that all conductors in slots of the same number are all cutting the same number of magnetic lines at any instant. The curved lines running around the outside of the diagram marked "E," are the end connections between the different groups of coils. In this diagram the coils are shown as having pointed ends. These pointed portions merely represent the ends of the coils where they pass from one slot to another. In actual windings each coil is generally composed of a number of turns of wire, but for simplicity only one wire is shown. In any case the connections between the coils would be the same whether one or a dozen turns per coil are used.

Dissimilar Grouping.

Sometimes it is impossible to divide the number of slots evenly by the number of poles or the number of slots per pole by the number of phases in which case the grouping must be made dissimilar. In such a case it is advisable to keep an equal number of coils in each phase, especially when the coils are connected in delta. For if the voltage in one coil were greater than in another, as would be the case with an unequal number of coils, a circulating current would flow which would cut down the capacity of the machine and cause undue heating. The same would be true for any winding in which an unequal number of coils is connected in parallel.

Such a system of winding is shown in Fig. 6. In this case there are 30 lsots and 4 poles. Here it is necessary to divide the grouping so that there will be two and three coils per group, as may be seen by following out any one phase. In this diagram as in Fig. 5, the phases are distinguished from one another by being drawn with different kinds of lines.

Pitch of Windings.

The number of slots in the stator divided by the number of poles gives the length of the pole arc expressed in terms of slots. A full pitch winding is one in which the effective span of the coils is equal to the pole arc or pole pitch, a fractional pitch winding is one in which the effective span of the coils is not equal to the pole arc as is shown in Fig. 7. Such a winding is sometimes called a variable pitch winding. The other two windings are placed similarly to the one shown and then connected in delta or star. This diagram represents a fractional pitch, three-phase, six-pole loop winding with 36 slots, 2 coils per slot, 2 coils per group. The throw, in Fig. 5 is 1 to 7, while in this case it is 1 to 6. In a lap winding with 2 coils per slot the effective span of the coil is equal to the actual span of the coil. In this case the span of the full pitch winding is equal to the total number of slots divided by the number of poles plus one.

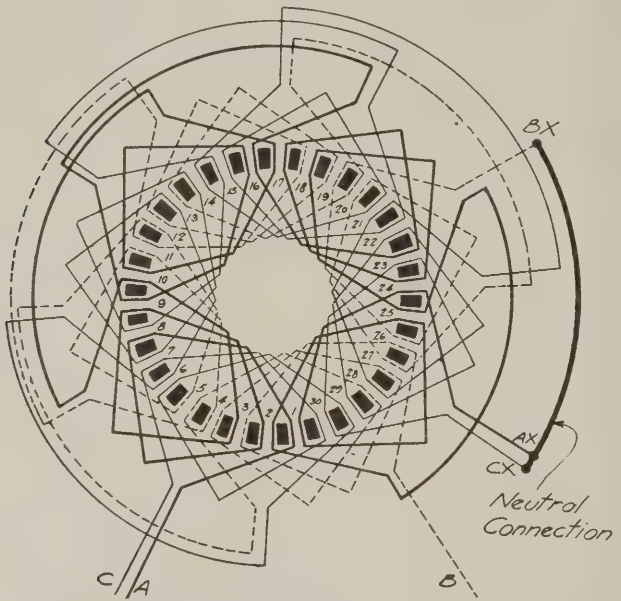


Fig. 6. Diagrammatic Representation of a Three Phase, Four Pole, Star-Connected Winding With Dissimilar Grouping of Coils.

There are many different conditions that will arise with the winding of different machines relative to the pitch and throw of the coil but each case must be worked out before the end connections are made. These diagrams show only a few slots as compared to the actual number found in such machines. The reason for this is that in practice a larger number of coils per group is used and parallel windings are frequently used to increase the capacity of the machine. This latter type of winding will be taken up in a future article.

When it is necessary to use dissimilar groups, as explained in connection with Fig. 6, a fractional pitch is necessary. So in Fig. 6 the real pitch is, 30 divided by 4 or, 7½ slots and the nearest lower even pitch gives a throw of 8 slots. By making use of both even pitches the average pitch is made 7½. The effect of a fractional pitch on the performance of a machine is similar to a reduced number of turns in the winding, but the effect is not proportional. In a generator this reduces the voltage of the machine, while in the induction motor the maximum available torque is increased but the magnetic density is also increased with a resulting reduction of the power factor.

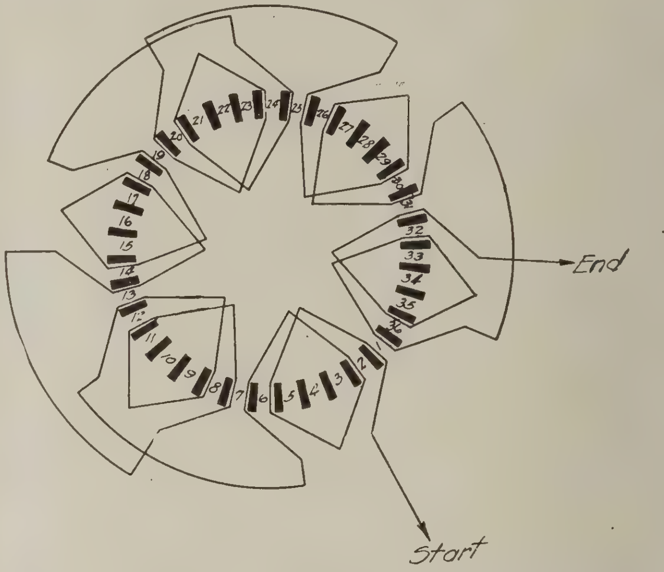


Fig. 7. Fractional Pitch Three Phase, Six Pole Group Winding.

New Multiplex Telegraph.

A few years ago, the Western Union Telegraph Company found that some means would have to be found to take care of their increasing business. Two alternatives were opened to them, they could either use their present line facilities more economically, or build additional lines and operate them under their present system.

The former was undoubtedly preferable. In the past there have been several telegraph systems which have written out the message automatically at the receiving end, among them the Buckingham, the Barclay and the Murray page printers. About 90 words per minute could be sent in each direction with these systems, or an effective transmission of about 170 words per minute. By combining the Baudot multiplex tape printer and the Murray page printer a reliable page printing telegraph system has been obtained which will send four 45-word per minute messages in each direction, or 360 words per minute. With the manual Morse system, but 25 words can be sent per minute.

This system seems to be the best and most comprehensive yet produced. By this system a message is printed on a modifyed form of typewriter. This typewriter perforates a paper tape which is then run through a transmitting machine which causes certain electric signals to pass over the line. These signals in turn operate the printing mechanism at the receiving end of the line, which prints the article in final form.

The advantage of this system can readily be seen, for it will mean that it is not necessary to condense and abbreviate articles for telegraphic transmission. This instrument should find a field in railroad work where extended and accurate orders are to be sent.

This machine has been developed and perfected by the Western Electric Co.

The Principles of Alternating Currents

Williard Doud

In the February number of the RAILWAY ELECTRICAL ENGINEER, the principles on which the simple alternating current generator is based were explained in detail.

By means of diagrams and by comparison with the workings of a hydraulic pump it was shown that the flow of current from the generating coil reverses in direction and rate of flow twice during each revolution of the coil. It was also shown that the generation of direct current differs from that of alternating current only in that the direction of flow during the two halves of the cycle is made continuous instead of reversing in character.

Alternating current systems of distribution in general use are single phase, two phase (quarter phase) and three phase. Definition of the word phase in its application to alternating current designation is rather difficult, it has the meaning of position but it will perhaps suffice to say that single phase current is a single series of alternating impulses or waves transmitted over a single circuit.

Two phase current may be defined as a double series of impulses or waves which have a difference of phase position equal to a quarter of a period of 90 degrees, transmitted over two circuits and three phase current as a triple series of impulses of waves 120 degrees out of phase with each other, transmitted over three circuits.

Frequency.

Present day requirements, in the main call for the use of alternating current which reverses in direction from 3000 to 7200 times each minute. The rapidity of reversal is termed *frequency* and a combination of one positive and one negative reversal or impulse is termed a *cycle* which is generally expressed by its rate per second. Current reversing 3000 times per minute is called 25 cycle and that reversing 7200 times per minute, 60 cycle current Special requirements and foreign usage sometimes call for variation from the above frequencies, but under ordinary conditions 25 and 60 cycle current is practically standard in the United States.

Twenty-five cycle current is used for long distance transmission and in work where the low frequency is not objectionable. A low frequency current cannot be used for lighting purposes as the lights will flicker when the rate of reversal drops below a certain figure. A frequency of 60 cycles has been found to meet the requirements of power and lighting in a very satisfactory manner and as a result it is used almost entirely in the commercial distribution of electricity for lighting and power purposes.

A definite relation exists between the speed, number of poles and the frequency of alternating current generators and motors and may be expressed by the equation—number of poles equals alternations per minute divided by the revolutions per minute.

A comparison of the R.P.M. necessary to produce 25 and 60 cycle current with generators having a certain number of poles is given in the following:

	Revolutions per minute	
No. of Poles	60 Cycles	25 Cycles
2	3600	1500
4	1800	750
6	1200	500
8	900	375
10	720	300
12	600	250
16	450	187

The current produced by an elementary A.C. generator is single phase current and in explaining the action of the simple generator in the preceding article all of the characteristics of single phase current which will be considered at this time have been covered.

The explanation of single phase current generation is comparatively simple and possesses few of the complications met with in the treatment of polyphase currents or those consisting of more than one phase. By consulting the diagram in Fig. 3 of the February issue, it will be seen that there are two points in each cycle where single phase current has zero values, namely at "A" and "C," the points of reversal. These periods of no flow, brief as they are in 60 cycle current, present formidable obstacles to the application of single phase alternating current for general power purposes. While entirely satisfactory for lighting and special power application it has been found that the generation and distribution of large amounts of electricity can be effected with better economy if two or three phase current is used. The polyphase motor and generator is lighter and cheaper to manufacture than single phase machines of like capacity and the polyphase motor is simpler, less liable to get out of order and has better starting characteristics under conditions of varied loading.

Elementary Two Phase Generator.

By adding a second coil to the elementary A.C. generator and placing its plane on the axis of rotation 90° from the plane of the first coil, a current will be produced by one coil which will have a maximum value when no current is flowing in the other coil and vice versa. The current and voltage produced consists of two series or phases of successive impulses sent out by two coils operating in a magnetic field and which are separated by a fixed angular displacement. The amount of phase displacement is measured in degrees for the reason that practically everyone is familiar with the process of dividing the circumference of a circle into 360 parts or degrees and using the degree unit in measuring any angle formed by two lines drawn from the circumference to the center. Explanation will be made later on of a process called Vector Summation into which the circular or degree system of measurement plays an important part in determining various characteristics of polyphase currents.

Fig. 7 shows in diagrammatical form an elementary generator arranged to produce two phase current.

It will be noted that the generating coils are separated from each other by an angular displacement of 90 degrees and that the current is transmitted from the coils through four collector rings to an outside circuit the parts of which are styled Phase 1 and Phase 2. Where four wires are used the circuit is known as

4 wire two phase and when two wires are combined and three wires are shown the circuit is called 3 wire two phase.

Certain numerical values are shown in connection with these circuits which will be referred to later.

Hydraulic Anology of Two Phase Generator.

The action of a two phase generator may be conveniently illustrated by means of a hydraulic pump consisting of two cylinders of the same size, the cylinders located an equal distance from and 90 degrees apart in relation to a common driving shaft with the cylinders connected together by a system of piping. Such an arrangement is shown in Fig. 8 and in comparison with Fig. 7, it will be seen that the cylinders displaced 90 degrees correspond to the generating coils separated by an equal angularity, the two pipes leading from each cylinder as the two circuit wires of Phases 1 and 2 brought out through the collecting rings and the combination of the four pipes into three to the joining of adjacent wires of phases 1 and 2.

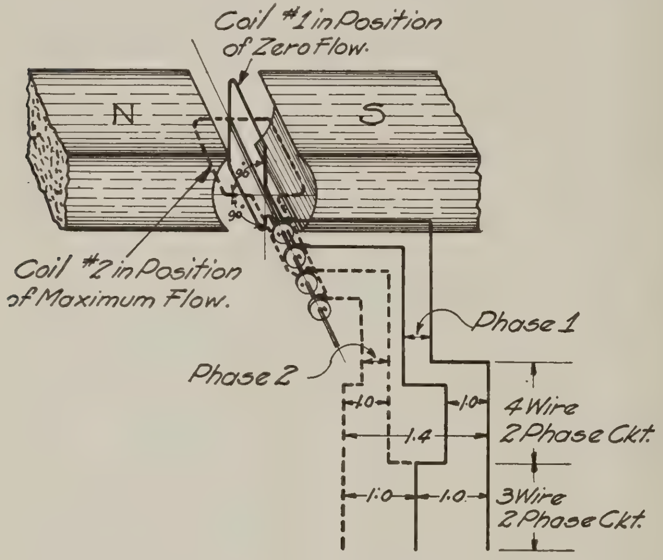


Fig. 7. Elementary Two Phase Generator Showing Both a Three and Four Wire Circuit.

By following the action of the cylinders in forcing water through the piping it will be noted that when the piston of cylinder 2 is in a mid position in the cylinder and consequently is delivering water at the highest rate and pressure, the piston in cylinder 1 is at the end of the cylinder ready for reversal therefore no water is flowing into or out of the cylinder or the piping connected thereto. A study of the action will show that on account of the maximum flow and pressure not occuring at the same time in each of the pipes leading from the cylinders two of the pipes may be combined into one of larger size, and as the size of the larger pipe need have an area only large enough to handle the maximum flow at any time, a distinct saving in the amount of piping required is effected.

For the purpose of illustration let it be assumed that the maximum rate of flow through the pipes leading from the cylinders is 100 gallons per minute. Then the rate of flow in the common pipe would be 1.4 times 100 or 140 gallons per minute.

Vector Addition.

The process by which the relation between amount of current flowing and the voltage or pressure value may be determined at any instant is rather interesting and involves the use of vector addition referred to previously in this article.

If two alternating electromotive forces are connected in series and they agree in phase the voltage at the terminals of the circuit will be equal to the arithmetical sum of the forces or voltages as in the case of direct current. If, however, the alternating electro motive forces differ in phase, the terminal or resultant voltage will not be the sum but a quantity differing from the sum according to the amount of phase displacement or angularity between the two forces which are combined.

It is highly important that the following principles outlined in the formation of the two phase diagram which follows, be thoroughly mastered as in the study of polyphase currents it is very necessary to be able to combine electro-motive forces and currents in order to obtain the magnitude and phase of the resultant of the forces or quantities.

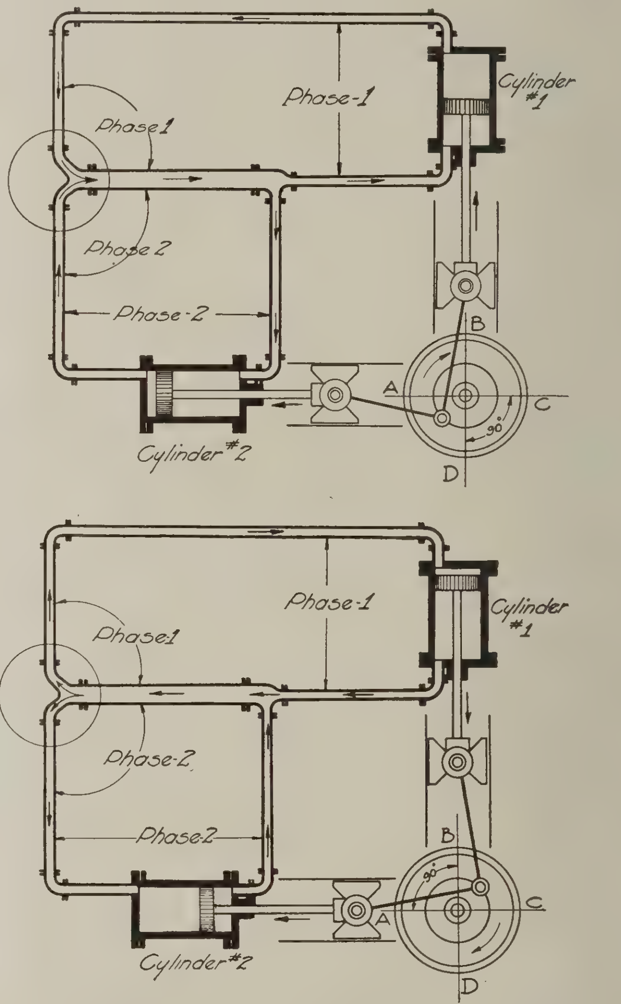


Fig. 8. Hydraulic Analogy of a Two Phase Generator Showing Direction of Flow for Different Crank Positions. The Direction of Water is Analogous to the Current Flow of a Two Phase Generator Connected to a Pure Resistance.

The combination of voltages will first be considered. In a two phase generator the voltages or pressures in the two phases are held rigidly 90 degrees apart by the fixed position of the coils in the machine. If we will draw two lines having lengths proportional to these voltages, placing them 90 degrees apart, and join them by adding two lines parallel and equal in length to the first two lines, a parallelogram will be formed, the diagonal of which will represent the resultant of the combined forces as shown in Fig. 9.

Fig. 9 shows a vector diagram for two phase current by means of which the resultant of combining either current or voltage of the two phases may be obtained.

The line O A has a length proportional to 100 volts, the assumed potential existing in one phase of a two phase generator. Line O B represents voltage of the other phase, and also has a length proportional to 100 volts and joins line O A at an angle of 90 degrees. Completing the figure by adding dotted lines A C and B C the diagonal formed by connecting corners O and C will be found to have a length equal to 140 volts based on the same unit of measurements used in laying out lines OA and OB.

In a similar manner the resultant of combining the current flowing between phases of a two phase generator may be obtained by using the diagram shown in Fig. 9 if the currents were in phase with the voltage. If the line OD represents 5 amperes flowing in phase A and line OE represents 10 amperes flowing in phase B, the currents will be 90 degrees out of phase with each other. The diagonal or resultant OF obtained by completing the parallelogram will represent the resultant current flowing between the two phases will be 11.2 amperes.

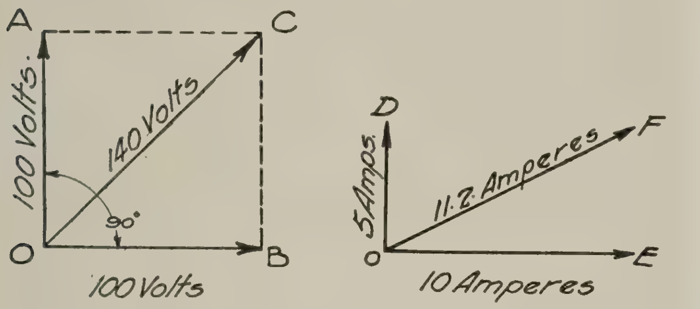


Fig. 9. Method of Combining Voltage and Current Vectors which are Out of Phase with Each Other.

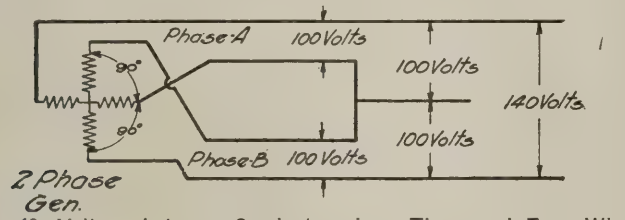


Fig. 10. Voltage between Conductors in a Three and Four Wire Two Phase Circuit.

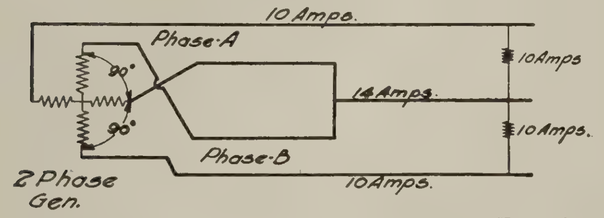


Fig. 11. Current Flow in a Three and Four Wire Two Phase Circuit.

The results of the above vector diagram analysis of two phase currents shows that the voltage between any two phases connected in series is 1.4 times the voltage of either of the phases. In the handling of two phase problems the resultant figure 1.4 is rather important and should be fixed in mind.

Fig. 10 shows diagrams of circuits leading from a two phase generator with the voltage values the same as shown in Fig. 9 for each phase and the resultant values obtained by use of the vector diagram. Both three and four wire circuits are shown.

Fig. 12, which is a geometrical representation of the instantaneous values of two phase pressure and current during one cycle shows the instantaneous values of voltage and current for each of the two phases, their relation to each other and their resultant. A study of the curves No. 1 and No. 2 represented by solid and dot and dash lines respectively will show that each curve taken separately is similar in every respect to the curve shown in Fig. 3 and differs only in that similar values are removed 90 degrees from each other, or the same as the angular displacement between the generating coils in the simple two phase generator shown in Fig. 7. Another characteristic of two phase current, namely that when the current flowing in one phase is at a maximum, there is no flow in the other phase is very clearly shown by consulting points B1 on curve 1 and A2 curve 2. At this instant B1 is at a maximum and A2 is of zero value.

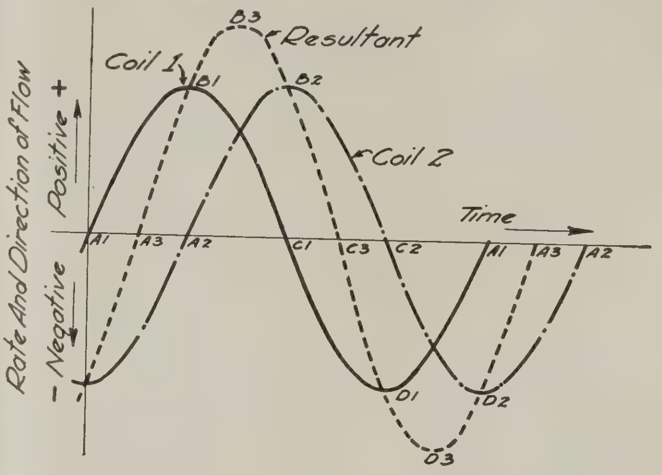


Fig. 12. Instantaneous Values of Two Phase Voltage Over a Period of One Cycle. The Resultant Voltage of the Two Coils in Series Shown by Dotted Lines.

In representing the characteristics of alternating currents by means of curves similar to Figs. 3 and 12 it has been assumed that the current and voltage are in step or in phase at all times and as such have equal values. Such a condition is not met with in practice and the effect of certain influences which are not encountered in direct currents and which tend to change the values of voltage and current in alternating currents will be discussed in a future article.

Electric Arc Welding.

At a recent meeting of the A. I. E. E., in Cleveland, Mr. J. F. Lincoln presented an article on electric arc welding, taking it up from the standpoint of the manufacturer and its adaptability for manufacturing processes. One of the greatest advantages of the electric arc for welding purposes is the general prevalency of electricity and the ease with which such a weld can be made. It has been open to the objection in the past, however, that a metallic oxide is formed which is detrimental to the weld and undue expansion and contraction takes place in the metal as well as burning. These various points were discussed and methods of obviating the difficulties suggested. Mr. Lincoln pointed out that it does not require as great skill to make an electric weld as it does to make a hand weld on an anvil so it could replace much of the manual work now done in the forge room.

In railroad shops both oxy-acetylene and electric arc welding methods are in use and so at the conclusion of this paper the discussion centered about the relative merits of these two systems. On this point Mr. Lincoln pointed out that with gas costing 2c a cubic ft. and with electricity at 2c per k. w. hour, electric welding would be from 3 to 30 per cent. cheaper.

The Railroad Electricians' Club

Lead Storage Battery Questions

Sealing the Covers.

Q.—112. Why is it costumary to either lead-burn the battery covers on or seal them in place with petrolyte?

Ans. 112. Various types of covers have been employed for car lighting batteries and these have been made of hard rubber, glass, lead, etc., in some cases being simply set loosely over the plate and in other cases hard rubber with a soft rubber lip flange making contact all around to the inside of the jar.

The latest practice seems to be to seal the hard rubber covers with petrolyte and where lead covers are used these are mechanically burned to the edge of the tank lining. Either of the two latter methods gives a cell which is substantial and which will not allow any of the acid to slop over or creep out of the cell in service. Ample means for the escape of gases is provided by the vent hole.

Wooden Trays.

Q.—113. Why are the lead tanks set in the wooden trays with a filling of hot petrolyte between? Is this necessary?

Ans. 113. It has been the general practice in recent years where lead lining tanks are employed to set these into thin trays with a filling of hot petrolyte between. This petrolyte is for a double purpose of insulating the lead lining at the bottom of the sides and also to prevent the wooden tank from soaking up acid on its inside surface. This petrolyte is not at all necessary provided proper wooden trays are made.

On page 295 of our February number we described a wooden tray in which the sides were open and in which no petrolyte whatever is used. A large number of cells so mounted are now in service, giving perfect satisfaction, in fact seem to have many advantages over the completely enclosed type in which petrolyte filling compound is used.

Comparison of Various Battery Jars.

Q.—114. What are the relative advantages of the lead lined tank versus the hard rubber jar, and also versus the stoneware jar? Are glass jars ever used for car lighting batteries?

Ans. 114. One of the chief advantages of the lead lined tank is that it will not break with severe vibration such as is experienced frequently in railroad service. It has many disadvantages, however, the chief of which are pitting, due to grounds, its weight, cost, etc.

The hard rubber jar is much lighter but more expensive than the lead jar and is easily broken with rough handling in service or while being cleaned. The hard rubber jar, however, will not be affected in any way by grounds, in fact is a good insulator for the battery. It is not affected by the acid of the electrolyte and should last indefinitely in service unless broken by rough treatment.

The stoneware jar seems to have many advantages for car lighting service and contrary to expectations it is standing up well under the severe vibration experienced in this service.

Glass battery jars have been used for many years as standard for large station type batteries and we are informed by one of the foreign manufacturers that several hundred sets of 100 ampere hour capacity batteries have been put into car lighting service in India recently. No information is given, however, as to the result of this experiment.

Rollers Versus Skids.

Q.—115. What are the relative advantages of porcelain or composition rollers versus porcelain or composition skids for supporting the battery tanks?

Ans. 115. It has frequently been found where 2 in. rollers of porcelain or composition have been used that with constant vibration in service and with the floor of the battery compartment more or less dampened with flushing, etc., that the rollers have gradually cut down into the softened wood floor until in many cases the hub came in contact with the floor, causing a ground. This would be impossible with skids of porcelain or other composition. The chief reason for using rollers is to make it easier to handle the battery but rollers are much more liable to be broken in handling the battery than solid block skids are. It would seem that taken on the whole the block skids are more satisfactory and more reliable than the rollers.

Q.—116. Why are insulating skids or rollers necessary; why not set the tray right down on the battery compartment floor?

Ans. 116. The potential of every lead lined tank is about the same as the potential of the negative plate of that cell. Therefore if there were no insulating skids or rollers, and after the wooden tray had become acid soaked, there would be a flow of current from the tank near the positive end of the battery, through the ground connection to the tank or tanks grounded at the negative end of the battery; this would cause the tank or tanks near the positive end of the battery to become pitted.

Edison Storage Battery Questions.

Voltage.

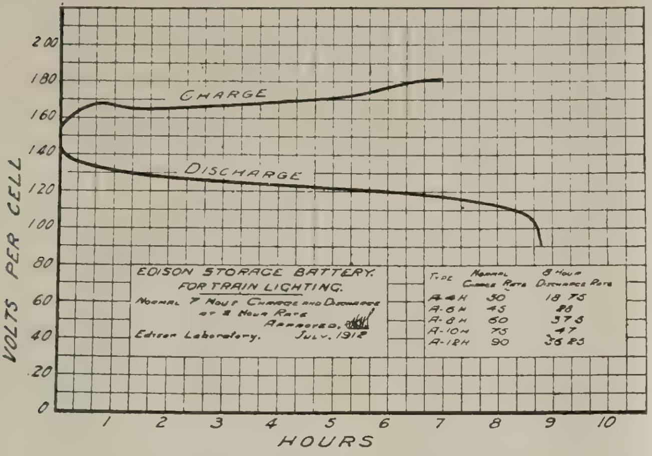
Q. 1. What is the voltage of an Edison cell?

Ans. 1. Like the lead battery, the voltage which an Edison nickel iron cell will give on discharge depends upon its condition of charge, discharge rate, and temperature. Generally speaking, however, it may be said that the voltage of an Edison cell is 1.2 volts per cell. The voltage on discharge is approximately 1.4 volts at the beginning and 1.1 volts at the end of discharge, as shown by the accompanying curve, top of page 343.

The Elements.

Q. 2. What do the elements of an Edison battery consist of?

Ans. 2. The active material of the positive plate is



Curves of Charge and Discharge.

made up of thin layers of nickel hydrate pressed firmly in a steel tube with thin layers of conducting nickel plate between. The negative active material consists of metallic iron or iron oxide, depending upon the state of charge.

Electrolyte.

Q. 3. What does the battery solution or electrolyte consist of and how can this be prepared?

Ans. 3. The electrolyte of an Edison battery is a solution in distilled water of potassium hydrate and lithium hydrate in definite proportions. It is highly necessary that these materials be of unusual purity and that traces of certain common impurities be especially avoided, and it is, therefore, required by the manufacturers that solution prepared by them be used without exception. A battery consisting of 26 cells of the A8H type will require approximately 21.6 gallons of renewal solution. The normal specific gravity of the electrolyte is 1.200 although it may vary from 1.160 to 1.250 without seriously affecting either the battery capacity or its efficiency. The specific gravity of standard renewal solution is about 1.250, but when it is introduced into the cell it mixes with a portion of the former weakened solution which is absorbed by the plates, and, therefore, cannot be poured out, and consequently quickly falls to a value considerably lower than 1.250.

Principle of Battery Action.

Q. 4. What is the chief difference between the chemical action that goes on inside an Edison battery on charge and discharge and that of a lead battery?

Ans. 4. The chief difference between the chemical action in a lead battery and in the Edison battery is that in the Edison battery the electrolyte does not combine with the active materials of the plates in the same way as it does in the lead battery. It acts as a conductor of the current from one group of plates to the other, and its decomposition furnishes oxygen in the free state at one electrode, and hydrogen in the free state at the other. Its specific gravity does not materially change during the operations of charge and discharge.

In the lead battery the electrolyte not only serves as the conducting medium, but on discharge the sulphuric acid enters both plates, and on charge it is driven out of both plates back into the solution.

This feature has both its advantages and its disadvantages. Its chief advantage is that since there is no chemical combination between the active material and the electrolyte, whether charged or discharged, plates are in no way injured by letting the battery stand indefinitely in any condition of charge. While on the other hand, if a lead battery is left in a discharged condition the sulphate of the electrolyte will soon chemically combine with the active material of both plates, forming white lead sulphate, which may seriously injure the battery.

The disadvantage of this fact is that the gravity of the electrolyte is no indication of the condition of the battery charge on an Edison battery, while with a lead battery this is a most reliable and useful indication of the state of battery charge.

Positive Plate.

Q. 5. How is the positive plate made?

Ans. 5. The "A" type positive plate is made up of 30 small perforated steel tubes 4⅛ in. long, while the "B" type is made up of 15 similar tubes. These tubes are filled alternately with layers of nickel hydrate active material and layers of nickel flake, as shown in Fig. 1. Each layer of the material has its place in the tube and is tamped solidly into place by a little steel ram-rod which fits the inside of the tube. The microscopic examination of the tube, as shown in Fig. 3, clearly shows the construction of the tube. The vertical walls are the edges of the steel tube, the white layers are nickel hydrate, and the thin dark layers are flaked nickel. There are about 300 layers of each kind of material in the positive tube 4 in. long.

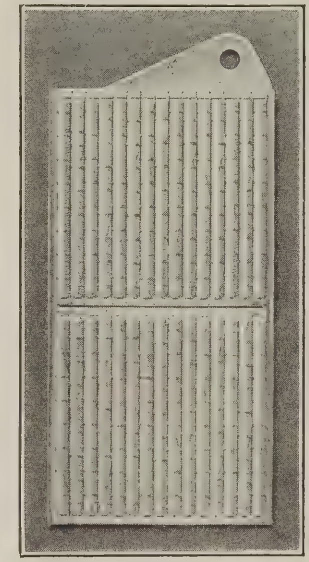


Fig. 1. Positive Plate.

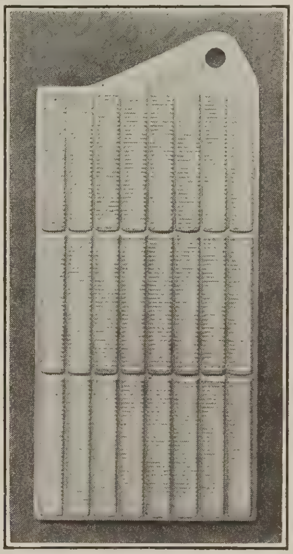


Fig. 2. Negative Plate.

The positive tubes are made from a perforated band of nickel plated steel which is twisted and the edges locked together on the spiral, as shown in Fig. 4. After the tubes are filled, steel band reinforcing rings are applied and the ends of the tube are flattened out, as shown in Fig. 4. This gives a very strong tube construction which resists swelling of the active material in service. The frame is slotted at the inner horizontal edges and then folded in such a way as to make individual clamping jaws over the flat ends of the tubes. This clamping is done under tremendous hydraulic pressure of many tons, so the plate as finally formed has great strength and rigidity.

Active Material of Positives.

Q. 6. Why is the active material built up in layers with thin sheet of metallic nickel flake between?

Ans. 6. The active material, nickel hydrate, does not have as low a resistance as some other materials, such as oxide of iron or peroxide of lead, therefore, layers of metallic nickel are inserted to conduct the current from the active material throughout the body of the tube to the steel wall of the tube, where it is conducted to the battery terminal posts. If it were not for the active material being divided up into thin layers with conducting layer of metallic nickel between, it would be impossible to make use of the capacity of the active material in the center of the tubes.

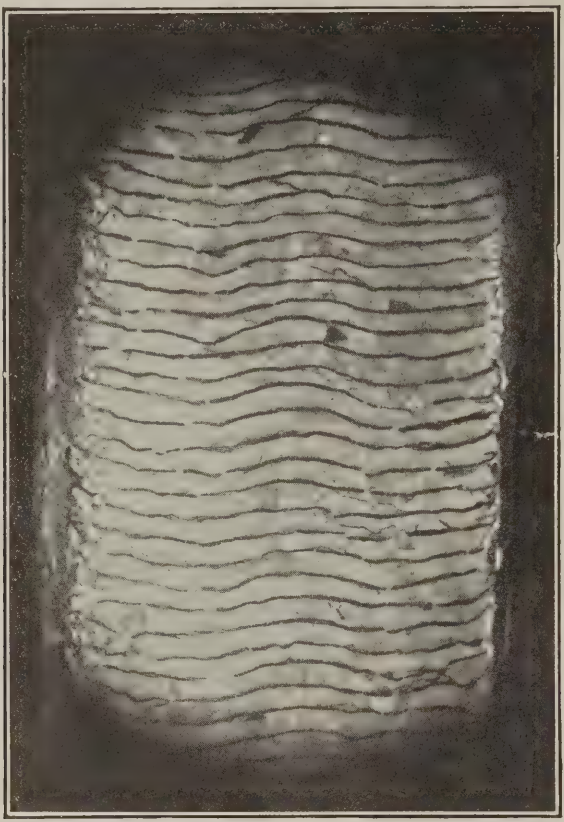


Fig. 3. Magnified Section of Positive Tube. The White Material is Nickel Hydrate and the Black Lines are Metallic Flake Nickel, Which Conducts the Current to and From the Active Material.

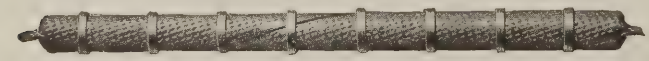


Fig. 4. A Positive Tube. Note the Spiral Joint and the Steel Ring Reinforcement.

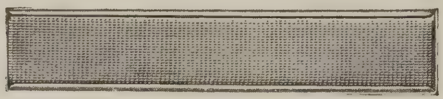


Fig. 5. A Negative Pocket.

Nickel Flake.

Q. 7. How is this flaked nickel made which is placed between the layers of active material in the positive tube?

Ans. 7. Flake nickel is exceedingly light, in fact, reminds one very much of snow, both as to its color and lightness. This is made by plating on large revolving copper or bronze drums very thin layers alternately of copper and nickel until a composite sheet of about 0.008 of an inch thickness is formed, consisting of 250 layers of nickel and copper alternately deposited. This sheet is then cut up into tiny squares about $\frac{1}{16}$ in. on a side and placed in a bath which dissolves out the copper and leaves the very thin flakes of nickel intact. This mass of nickel flake is then washed free from copper solution and dried.

Q. 8. Why go to all the trouble of making nickel in flake form, why shouldn't a solid sheet of nickel between layers of active material serve just as well?

Ans. 8. If you will look at the magnified section, Fig. 3, you will note that the layers of active material and nickel flake are irregular. It would be physically impossible to pack this active material in such thin layers in the tube and have the surfaces of the layer be perfectly flat and smooth. Since the nickel conducting layer is packed in flake form, however, it very readily conforms to the irregularities of the surface of the active material, making intimate and uniform contact at all points.

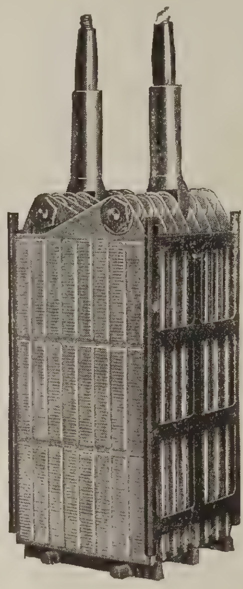


Fig. 6. The Elements with Separators in Position.

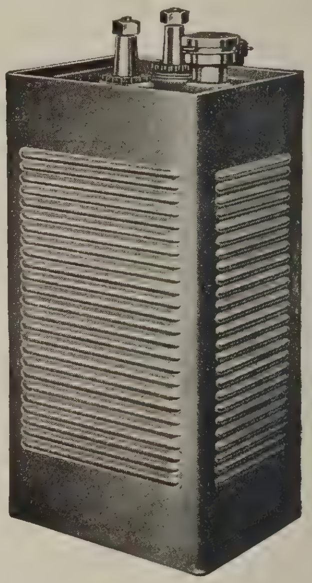


Fig. 7. A Complete Cell.

If this had been a solid disc of metallic nickel instead of flexible nickel flake, it would not have conformed to the surface of the active material and the contact with the active material would have been very uneven and in many places would fail to make sufficiently good contact with the active material. It will be noted, moreover, that the layers of nickel flake all make good contact with the sides of the steel tube. It would be very difficult to get an equally good contact where a solid disc of nickel were used.

Negative Plates.

Q. 9. How are the negative plates made?

Ans. 9. Negative plates are made up of nickel plated perforated steel pockets filled with finely divided metallic iron or iron oxide as active material. Both iron and iron oxide have good conductivity, therefore, no metallic conducting layers are necessary as in the positive plate.

Iron oxide is placed in the negative pockets, shown in Fig. 5, and these are assembled in the nickel plated steel frame, as shown in Fig. 2. The pockets are perforated with very fine holes which allow a free circulation of electrolyte and passage of current to the active material in the body of the plate and still at the same time hold the active material in place. After the plate has been assembled, as shown in Fig. 2, it is placed under a hydraulic press and a pressure of 120 tons is applied on the "A" type plate and 60 tons on the "B" type plate, which both brings the active material into good contact all around with the metal pockets and also forces the metal pockets solidly into place in the steel frame. This results in the negative plate being of strong and solid construction.

A. B. C. Car Lighting Course

Edited by Edward Wray

Lesson No. 39

Some Peculiar Things About Battery Grounds

Where batteries with lead lined tanks are connected up in series, as is done in car lighting, there is a potential difference of about 2 volts between the lead tank linings of adjacent cells such as A and B, Fig. 1, while there is 6 volts between tank A and tank C, and 10 volts between tank A and tank F, etc., as shown in the accompanying diagram, Fig. 1.

It has long been a well recognized fact that on some roads the rear tanks of all batteries become pitted more rapidly than the front tanks do, while on other roads the experience has been directly opposite to this; that is, that the front tanks have given practically all the trouble from pitting and leaking.

We have never heard a logical explanation as to why the experience on one road should be directly opposite to that of another road, but a suggestion by Mr. L. D. Smith, electrician of the Rock Island Lines, and which is elaborated upon by the editor herein, will doubtless serve to clear up the difficulty. Where the cells of the battery are so connected that the positive terminal comes to the right facing the battery as is the practice recommended by the A. R. E. E., and as shown in Fig. 1, it will be found that the forward tanks of each tray will become pitted far more rapidly than the rear tanks. This is not because of any more slopping on the front tanks than on the rear, as even we ourselves have been guilty of suggesting, but rather due to direction of current flow and potential difference between the adjacent tank linings, as explained later.

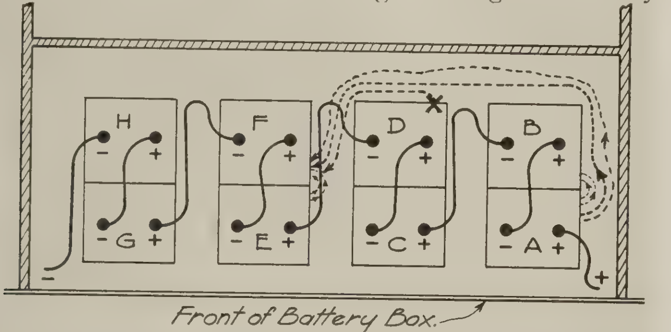


Fig. 1. Plan View of a Half Battery Showing the Location of Cells and Connectors; Dotted Lines Indicate Flow of Current Through the Car Frame From a Grounded Tank Near the Positive Terminal to Another Grounded Tank Near the Negative End of the Battery.

The lining of cell A shows a potential of 2 volts positive to the lining of cell B, therefore, if both cells are grounded or if the partition between them becomes acid soaked, a current will flow from the lining of cell A to the lining of cell B, as shown by dotted lines and arrows of Figs. 1 and 2.

Referring to Fig. 2, we will assume first that lining of cell A is exposed at the points marked "X," the balance of the tank surface being protected by the petrolyte; we will also assume that the wooden partition is soaked with acid and that the entire face of the lead lining of tank B is exposed to the action of the current, due to the acid having worked in between the tank and the lead lining. Since cell A is positive to cell B current will flow from the point on cell A to all exposed points on the surface of tank B.

Oxygen is liberated at all points wherever the current leaves any plate surface and enters the electrolyte, and hydrogen is liberated at all points where the current leaves the electrolyte and enters another plate surface. Therefore oxygen will be given off at the outer surface of the lining A, and hydrogen will be given off at the outer surface of the lining B. Since this current flows away from the lining A, and is concentrated at two points, X, as is shown in the diagram, Fig. 2, it will soon oxidize the lead lining at these points to such a depth as to eat entirely through the lining and allow the cell to leak. Whether the current is spread over a large area of surface on the lining B, as shown, or is concentrated at one point, the lining B will not be injured in either case since hydrogen is liberated over its surface and this does not in any way attack the lead; in fact, tends to preserve it.

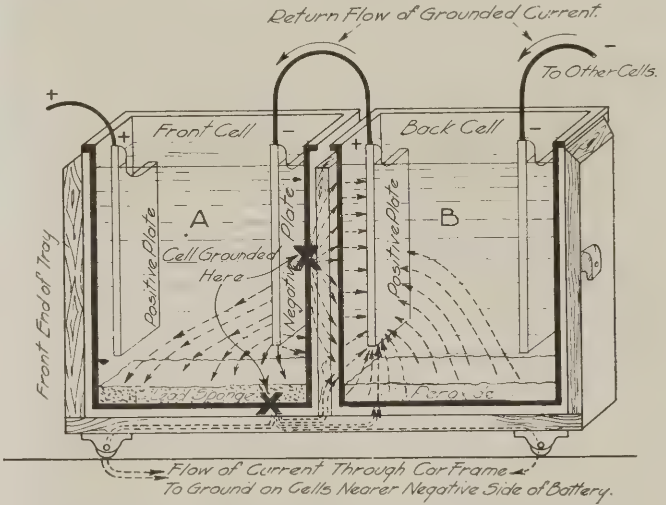


Fig. 2. Cross Section of Twin Cell Tray (Only Two Plates Per Cell Shown for Simplicity). Dotted Arrows Indicate Flow of Grounded Current. Note that this Current Flow Changes Sediment in the Bottom of the Front Tank to Lead Sponge and That in the Back Tank to Peroxide. This is a Sure Indication of a Ground on the Front Tank or an Acid Soaked Partition.

It is invariably found that where the forward cells are pitted or oxidized badly on the outside the sediment in the bottom of that tank is lead sponge, whereas the sediment in the bottom of the rear tank of the same tray is nearly always peroxide.

The explanation of this is simple, for the current which flows from the lining A to the lining B must flow from the negative plate through the electrolyte to the lead lining of cell A, as shown by the dotted arrows. For the sake of illustration, we have shown only one positive and one negative plate in each cell, but it will be readily seen that the current will flow from each plate of the negative group to practically all points on the inside surface of the lead lining A. Hydrogen will then be liberated in a slight quantity all over the inner surface of the lead lining A. Since active material is deposited as sediment in the bottom of the tank, either in the form of lead sponge from the negative plate or peroxide from the positive plate, this active material is quickly reduced to lead sponge by the chemical action of the hydrogen liberated by the grounded current flowing.

This current, then flows from all points on the inner surface of the lining A, through the metallic lead of the tank to the point X at which the outside of the tank A is grounded. It then flows through the acid soaked partition and in doing so liberates oxygen on the outer surface of the tank A at the points X, and this current also liberates hydrogen as it enters the outer face of the lead tank B. It is then distributed throughout the entire metal of the lining B, and enters the electrolyte of cell B from practically all points of the B lining; therefore, oxygen will be liberated uniformly over the inner surface of the tank B, and the active material deposited as sediment in the bottom of the tank will be soon oxidized to lead peroxide.

Therefore, wherever it is found that the sediment of the front cell is a strong slate color, indicating lead sponge, and the sediment of the rear cell is a bright chocolate color, indicating lead peroxide, it is a sure sign that the battery insulation of that particular tray is poor and that the partition between tanks will probably be found to be acid soaked. It will also usually be found that the outer surface of tank A is chocolate color, either in spots or over the entire surface, indicating peroxide, and if this is concentrated at one point pitting will occur there. Under these conditions the outer surface of the rear tank B will be found to be a bright slate color and the inner surface a chocolate brown. Wherever such conditions are found the battery has been grounded more or less, and the extent of the grounds is indicated by the strength of the color. If this is found to be serious, the wooden tray should be very carefully inspected and possibly discarded or at least should be soaked in water to remove the acid, then dried and given the usual boiling treatment with paraffin or petrolyte and rosin.

Where the bottom of the tray becomes acid soaked and the insulators are either buried in the soft wood lining of the battery compartment, or become thoroughly covered with acid so as to provide a path for the current, current may flow not only through the partition between the two adjacent cells of the tray, but also between this tray and any other tray in the battery which may be grounded, as shown by the dotted arrows, Fig. 1 and Fig. 2.

We will assume that both the tray AB and the tray EF are grounded. Current will flow both from the tank lining A to the tank lining B, as shown in Figs. 1 and 2, and current will also flow from this point to the lining of cell F. The current flowing from A to B will tend to neutralize the current flowing from B to F. Therefore, most, if not all of the current which flows from the tray AB, comes from the tank A, and similarly if both E and F are grounded, due to an acid soaked partition as was A and B, current will flow from E to F so the grounded current from AB will be diverted by the EF current and all will enter the cell F.

Therefore the cell A would be pitted badly by a ground on tray AB, but the tank B would not be pitted at all, and similarly, the tank E might become pitted while the tank F would be protected by the hydrogen liberated by the grounded current flowing *toward* that point. It is possible, however, for the rear tank in certain cases to become pitted, for if the ground occurred on the rear side of tank D, as shown, and another ground occurred on some cell nearer to the negative end, current would flow from the D tank to the other tank grounded.

Of course if another ground occurred on tank A or B or even C, the current flowing toward the ground on tank D might neutralize the out-going current and prevent pitting of the rear tank D due to this ground.

By observing the color of the sediment in the bottom of the front and rear tanks and also the coloring on the outside of the tanks it is very easy to determine which trays are grounded. Any tank which has mud in the bottom, which is the color of a normal negative plate is grounded and should be carefully reset in order to prevent developing a leak in a short time.

If the batteries are connected up in such a manner as to bring the negative on the right hand side facing the battery the rear tanks will become pitted more than the front ones, the entire action being just the reverse of this, as explained.

New York Central Makes Good Record.

The Harriman Memorial Gold Medal for the American Steam Railway making the best record in accident prevention and industrial hygiene affecting the public and its own personnel during the year ending June 30, 1914, was awarded to the New York Central Railroad.

The record of the New York Central for the year was considered remarkable in many respects. The progressive steps taken in the installation of block signals, improved roadbed, steel equipment and modern safety devices were taken into consideration, as well as the actual record of accidents. There has not been a passenger killed in a train accident on the road in four years, during which time the number of passengers actually carried on its trains equals approximately twice the entire population of the United States. Nearly three million freight and passenger trains were operated day and night in all kinds of weather. During the year ended June 30, 1914, as compared with the previous fiscal year there were 102 fewer persons killed and 1,068 fewer persons injured as a result of the Safety work on the road. It is reported that the road's record for the year ending December 31st is even better than the record for the fiscal year, the decrease in death cases being 32 per cent and injury cases 33 per cent over the previous calendar year. One of the interesting features of the road's record is in the efficiency of its employes as indicated by surprise tests wherein the employes without previous warning are tested as to their observance of signals set against them, as to flagging, blowing whistles at grade crossings, speed restrictions, etc. Out of 323,892 such tests made in the year in only 539 cases were the employes deficient, the percentage of efficiency being 99.58 percentum.

The work conducted by the road through its Safety Bureau, in educating its employes and the public in general to avoid unsafe practices, was one of the features wherein the road excelled. Substantial reductions were made in the number of accidents to trespassers and to persons on grade crossings, as well as to passengers and employes.

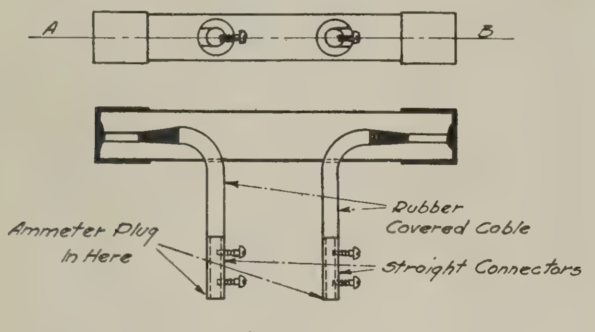
The record as to mechanical improvements on the road showed that the entire main line from New York to Chicago is now equipped with automatic block signals and one hundred pound steel rail laid on a heavy bed of rock ballast.

Practical Stunts

We Pay a Dollar Apiece for Practical Stunts—Send in Your Ideas

Ammeter Jack From an Old Ferrule Fuse.

It is often found necessary to insert an ammeter in a circuit temporarily. By means of the device shown in the accompanying sketch this can be done very easily.



Section on Line A-B

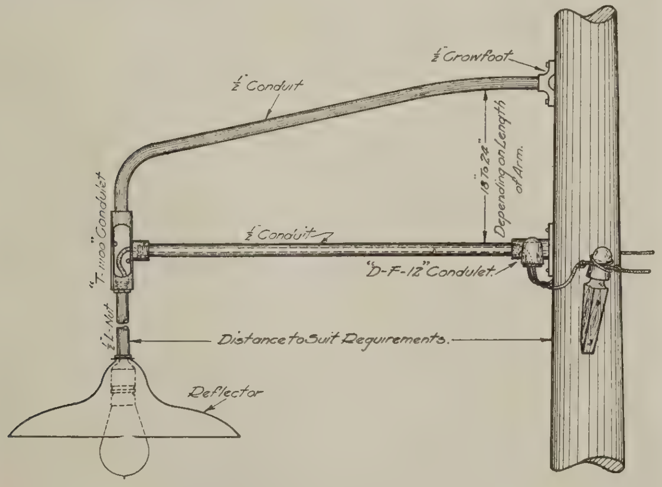
Showing Method of Connecting Leads to Old Fuse.

Take an old fuse that will fit the fuse box used on the circuit which you are testing and remove the packing, then drill two holes in the side large enough for the insulated wire to pass through. Insert two pieces of wire and solder the ends into the two caps of the fuse. On to the other ends of the leads solder two straight connectors as shown. Now all that is necessary in order to insert the ammeter into the circuit is to pull out one of the fuses and insert this device in its place and connect the ammeter to the two leads.

F. G. Phipps, Montreal, Canada.

Mast Arm for Mounting Lighting Unit.

We have recently designed and installed many mast arms for supporting lighting units from poles, as shown in the accompanying diagram. The mast arm is built up entirely of conduit and condulets and makes a very strong and serviceable support and at the same time is reasonably cheap.



Construction Details of Mast Arm.

A "T-11100" condulet carries the vertical section of a conduit supporting the reflector and also the horizontal ½-in. conduit run leading over to the pole. In the upper outlet of the "T" a bent section of ½-in. conduit with a crow foot screwed on the other end connects with the pole and acts as a diagonal brace, giving the mast arm great strength and rigidity. The horizontal section of the conduit connects to the pole by means of a "DF-12" condulet, through which the lead wires from the external circuit enter the conduit. The distance between the mast arm support on the pole and the crow foot supporting the diagonal brace pole, will vary from 18 to 24 in., depending upon the length of the mast arm. The length of the vertical section of conduit between the "T" condulet and the reflector will vary according to the requirements.

A. L. Chapin,
Asst. Elec. Engr., Illinois Central R. R.

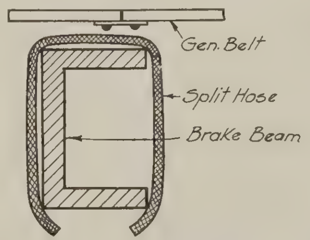
Peculiar Regulator Trouble.

The car lighting man often experiences trouble due to magnetic circuits being formed through the steel locker doors when they are allowed to come close to the regulator panels when the door is closed. Trouble from this source is very annoying and hard to find, due to the fact that when shooting trouble the door is open so that the repairman can watch the regulator. Naturally, nothing happens with the door open, so when he is satisfied that nothing is wrong, he closes the door and leaves the car.

This trouble can often be located by turning on lights, then opening, and closing the steel door. If this is causing the trouble, the voltage will usually rise and fall.—A. B. M.

To Prevent Loss of Generator Belts.

Here is a stunt to prevent the loss of generator belts, caused by their striking on the brake beam. This is caused by too little clearance between the belt and the brake beam. The belt will catch on the beam and ultimately be broken.



Hose Protecting Belt from Beam.

To prevent this loss of belts, split a piece of rubber hose and tie it on to the beam at the point where the belt strikes it. This will make a cushion and prevent injury of the belt.

Lack of belt clearance is one of the greatest causes of short belt life, but is a factor that cannot always be eliminated, so the next best thing is to make small clearance as harmless as possible.—S. W. Everret.

With the Manufacturers

The Safety Company's "Under-Frame" Equipment

The advance in design of steel trucks and steel car bodies, with the deep center girder, has increased the problems of axle generator suspension and belt clearances to such an extent that car designers and railway operating men have racked their brains to overcome the difficulties. The Safety Car Heating and Lighting Company has evidently recognized these problems for some time; and, as a result, this company now has in service a number of new equipments that seem to solve the mechanical and electrical problems of installation and operation. But, what is equally important in these times of forced economies, this new system provides a reduction of about 60 per cent. in weight of the generator and suspension, which is a saving in cost of operation.

This new system has been named the "Under-Frame" equipment by the Safety Company. As the name indicates, the generator and suspension are removed entirely from the car truck and are mounted on the car underframe. The advantages claimed for this method of application are as follows:—

Reduction of about 60 per cent. in weight of generator and suspension.

Removal of three-fourths of a ton of unsprung and overbalancing weight from car truck.

Increased clearances between end sill or brake rigging and belt.

Increased clearances between generator and track.
Decrease in wear of generator and suspension parts.
Increase in accessibility for inspection or repairs.
Ease of installation.

The use of a smaller armature pulley, obtaining a higher ratio between the axle pulley and the armature pulley is permitted by the increased belt clearances obtained with this equipment and the use of a belt fastener which operates properly with small pulleys. This gives increased operating speed of the generator. As the capacity of a generator is directly proportional to its speed, the weight of the generator used with this equipment is reduced forty per cent, compared with the same capacity generator which operates at a lower speed. This accounts for part of the decreased weight of this equipment; the greater reduction being affected in the generator suspension. The construction required for suspending the generator from the car underframe is much simpler than the truck suspension, as will be noted in Fig. 1, accomplishing a reduction of about seventy-five per cent in weight of the suspension. The total reduction in weight obtained by the use of this equipment is nearly 900 lbs.

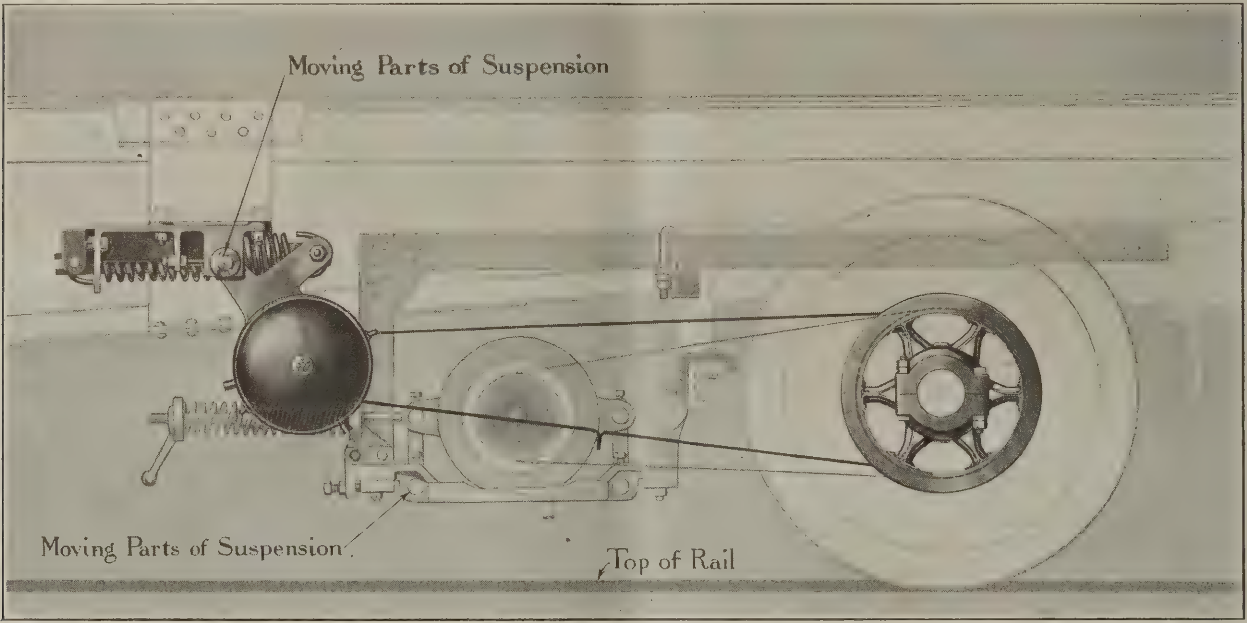


Fig. 1. Showing the Comparison in Size and Position of Safety Body Hung Suspension and Truck Suspended Equipment.

Of course it is obvious that transferring the entire weight to the car underframe does not remove the entire weight from the truck, but distributes and absorbs it properly through the bolster springs. Approximately a ton of overbalancing and unsprung weight is therefore removed by this system from the car axle carrying the generator and suspension. This is a consideration which will appeal to those responsible for the design and operation of cars, since the removal of this unsprung and overbalancing weight from the truck certainly simplifies the problems of design and operation.

Clearances.

Where the generator is attached directly to the car underframe, there is no relative movement between the generator and car body. This, together with the reduced diameter of the generator, provides for greater latitude in the location of the generator, so that the maximum clearance between the brake-rigging or end sill and the belt is obtained. Increased belt clearances, of course, mean increased belt life and increased reliability of operation.

With truck suspensions, the generator is very close to the roadbed, where it is frequently hit by flying ballast and where it acts as a collector of snow and ice in the winter months. This last condition is especially bad, since ice seriously interferes with the proper operation of the equipment. The clearance between the generator and the track or roadbed is considerably increased with this type of equipment; and what is more important, the moving parts of the suspension are located so high above the track as to be out of all danger from ice and snow. The moving parts of the generator suspension are also out of range of the dripping condensation from the traps on steam heating systems.

It is hardly necessary to state that there is a very noticeable reduction in wear when the generator is mounted on the car underframe and is carried by the car springs instead of on the truck frame.

Accessibility.

The generator of this equipment is mounted in such relation to the car body, car truck and track that the electrician can make an inspection without ever getting between the track rails, as shown in Fig. 2. Every part of the suspension and generator is most accessible for quick inspection or repairs.

It is obvious that a suspension which attaches to the car underframe is simpler to design and install than one which must be built up to overhang the end of a truck. As the belt clearances are greater, fewer changes will be found necessary to accommodate this type of equipment to the standard positions of the brake rigging and other parts located under the car.

Belt Tension.

The most important factor and real secret of the success of this type of equipment is the design of belt tension used. Proper belt tension is maintained at all times and under all conditions, and no adjustment of this belt tension device is required to maintain its proper operation. The changing angle between the car and truck, as well as the variable distance between the centers of the car axle and generator shaft caused by the car rounding a curve, are adequately taken care of by maintaining constant belt tension with any position of the generator. This prevents excessive belt tension when the distance between centers is lengthened and eliminates belt slipping when the distance between centers shortens.

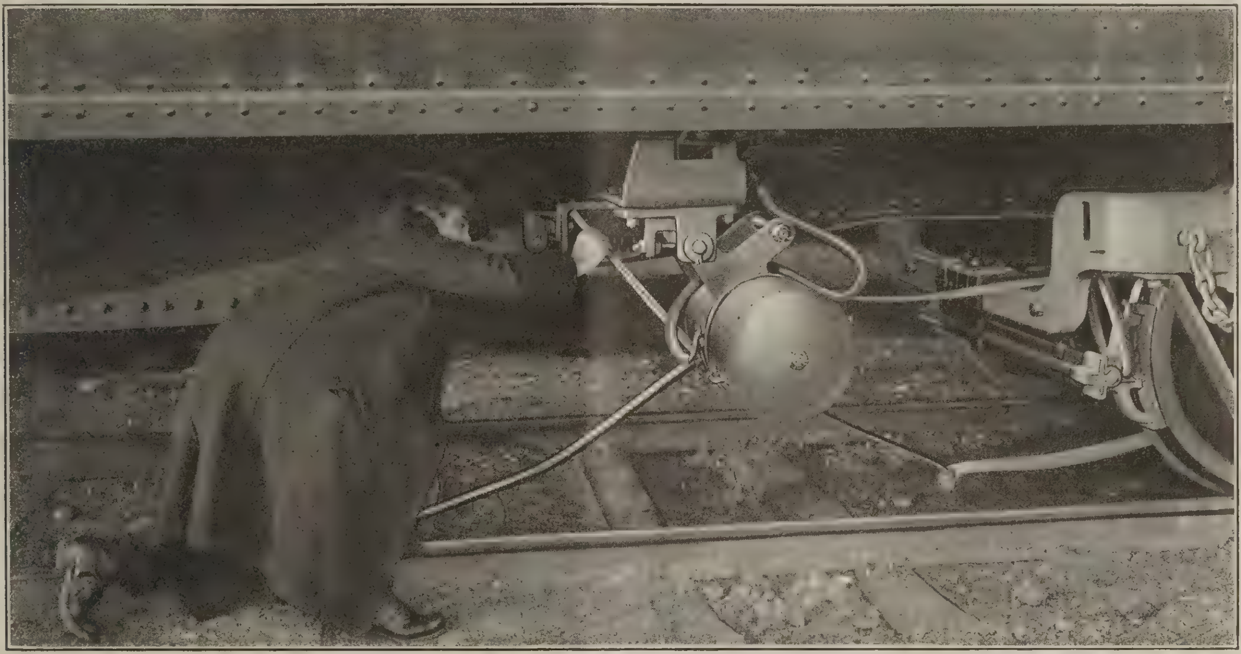


Fig. 2. Generator Blocked in the "Slack Belt" Position for Motoring and Inspection.

Operation of the Generator Suspension.

The generator with its suspension is shown in Figs. 3 and 4. Cast on the generator frame are the carrying lugs "a" which are pivoted to the supporting lugs "b" on the suspension casting by the suspension bar "c". The suspension casting is to be bolted to a suitable plate secured to the car underframe. Belt tension is maintained by the weight of the generator and by the tension spring "d", which engages at one end with a lug "e" on the generator frame; and at the other end with the bracket "f", fastened to the suspension casting. The parts are so designed that the sum of these two varying factors is constant. When the generator is hanging, as in Fig. 3, so that its center of gravity is directly under the supporting bar "c", the weight

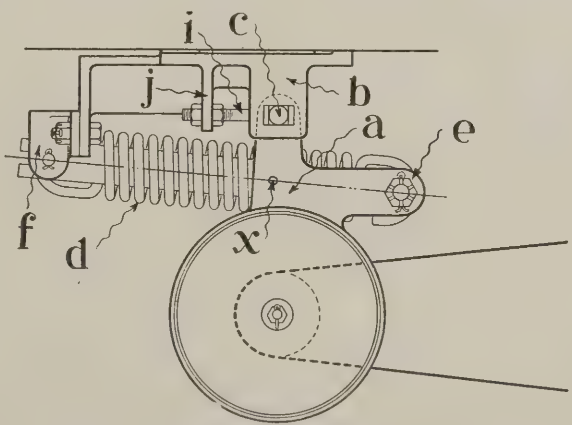


Fig. 3. Position of the Generator When the Distance Between the Car Axle and the Suspension is Normal.

adds nothing to the belt tension, but the spring "d" has its greatest effect, since the leverage on which the spring acts (the distance between "c" and "x") is greatest. If the generator is swung as in Fig. 4, the weight of the generator is giving tension, but the pull of the spring is decreased as the leverage "cx" is shortened; the sum of the two tensions being the same as in the first position. Ample latitude is provided between the two extreme positions of the generator (Figs. 3 and 4) to take care of belt stretch and the variation in distance between the generator and axle when the car is on a curved track.

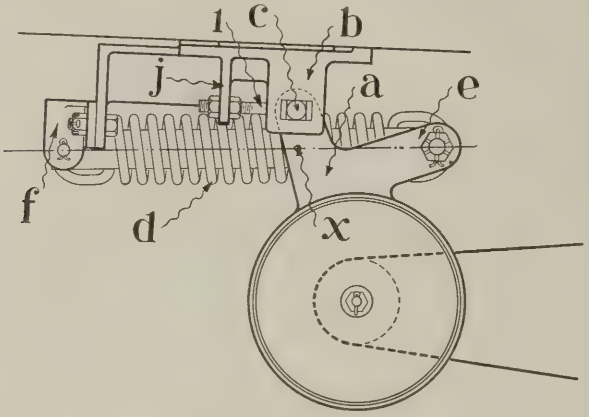


Fig. 4. Position of the generator and the spring tension rod when the car rounds a curve so that the distance between the axle pulley and the suspension is lengthened. When the car turns a curve in the reverse direction, the generator will swing over to the left of perpendicular and the leverage of the spring tension will then be increased so as to compensate for the weight of the generator, which then tends to reduce belt tension.

The tension spring is assembled on a carrier, under the proper tension, so that to apply it to the suspension it is only necessary to slip the two pins through holes in the carrier and corresponding holes in generator lug "e" and in the suspension bracket "f". This gives ease of application and assures the correct tension.

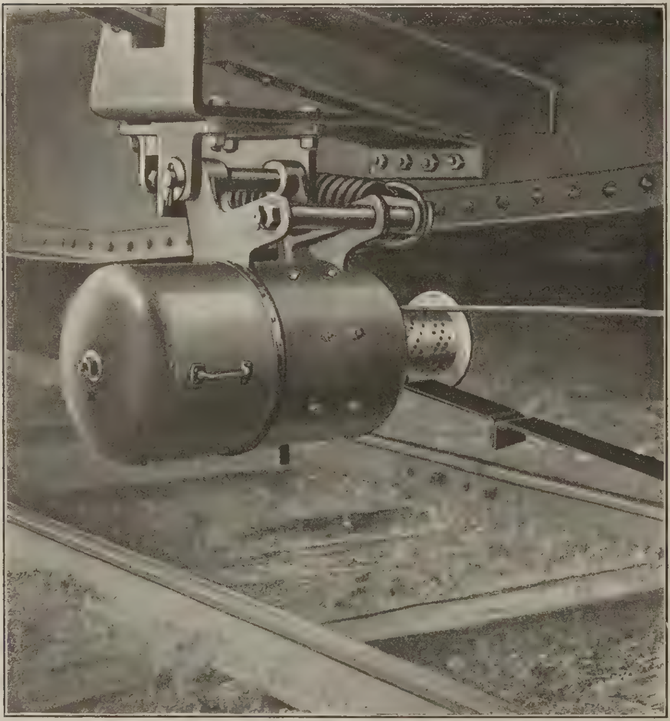


Fig. 5. A Simple Method of Installing "Under Frame" Equipment. Note the Special Type of Fastener Employed.

The arrangement for lining the generator with the car axle is simple. The hole in the lug "b" for the supporting bar "c" is slotted, and the position of the bar can be adjusted and locked by means of the bolt "i", which is provided with locknuts on either side of the lug "j".

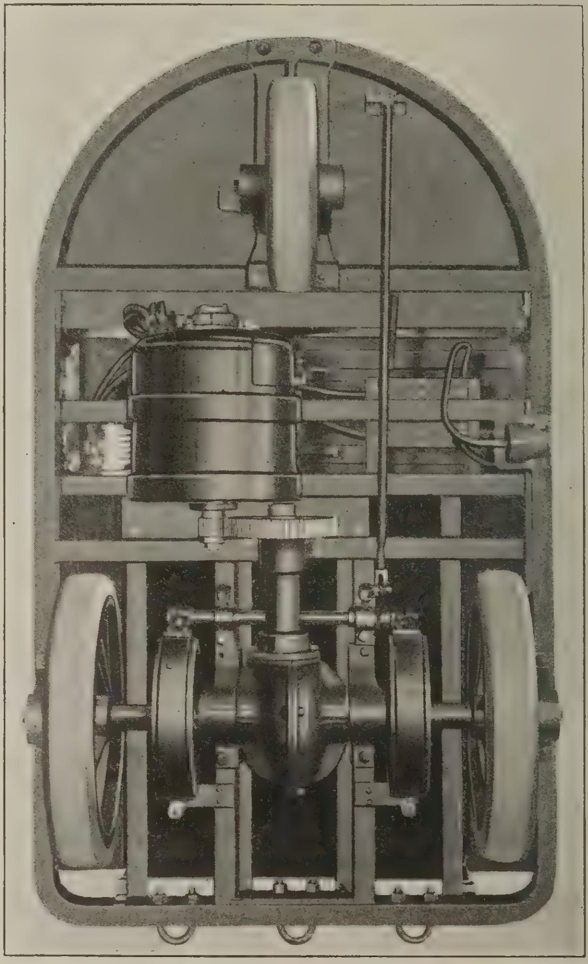
All wearing parts are hardened or provided with steel bushings and properly lubricated.

Fig. 5 shows the generator and suspension applied to a steel car and shows one simple method of attaching the suspension to the car, the clearance under the generator, and its accessibility for inspection.

The generator is a four-pole, shunt wound type with inter-poles which give sparkless commutation with the high speeds at which it is designed to operate. It has a capacity of 3 kw. (75 amperes at 40 volts).

New Storage Battery Tractor.

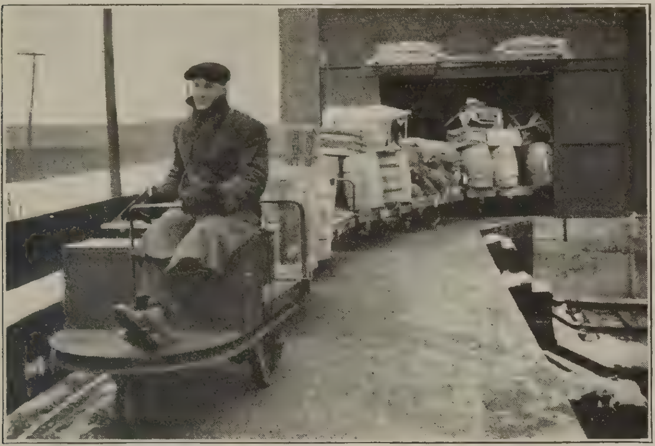
Railroad men are beginning to realize that it is more efficient to transport freight by means of a tractor pulling loaded trucks, than to use a number of motor trucks, each equipped with its own motive power. A tractor to pull has the advantage over the power unit that carries the load, in that the tractor and its operator need not be idle while loading or unloading. The use of storage battery trucks also means that a set of expensive batteries and motors must be duplicated on each truck.



Bottom View of Storage Battery Tractor Showing Arrangement of Motor and Brake Rigging.

The Mercury Pullem, as it is called, can be used to great advantage in handling flat trucks to and between departments. Trucks may be loaded and set aside where the Pullem can pick them up in making its rounds at regular intervals, thus saving the expense of providing each truck with a trucker. The tractor operator is kept continuously busy making his round.

The accompanying cut shows this storage battery tractor hauling a train of loaded trucks out of the freight house to the platform around a sharp bend.



Tractor Pulling Trains of Loaded Trucks Around a Sharpbend, Showing Accuracy with which Trailing Trucks Track.

This shows very well how nicely the trailing trucks will track, making the scheme very adaptable for freight house service. The tractor will operate in a five-foot aisle.

The tractor itself is well constructed mechanically, being equipped with high grade ball and roller bearings and special steel. The wheels are cast of semi-steel and tired with solid rubber tires. Steering is accomplished by a lever which turns the front wheel. The motor and its control are of a very rugged construction, needing very little attention.

The batteries are mounted in a box placed over the rear axle, concentrating most of the weight of the tractor on the driving wheel. The make of batteries furnished is left to the option of the buyer.

Edison Exhibit at Panama Exposition.

The main exhibit of the Edison Storage Battery Company, Orange, N. J. is in Block 12, Palace of Transportation, between the exhibits of the Standard Oil Company and the Ford Motor Company. They have a space of about 50 feet frontage, with a depth of 30 feet, with practical exhibits of batteries for electric commercial trucks, industrial trucks, passenger electrics, etc., together with a complete apparatus for house lighting installations, marine lighting equipments, railway train lighting equipment, railway signaling equipment, etc.

Associated with them in this space is the Primary Battery division of Thomas A. Edison, Inc., where the Edison Primary Battery for closed and open circuit work is shown, with its applications to railway signaling, marine ignition, police, fire and burglar alarms, annunciator systems, etc.

In the Machinery Building the Edison Storage Battery Company has an exhibit in Block No. 21 in connection with the W. J. Marland Collective Exhibit, where storage batteries are shown and their application to vehicle, railway, house lighting and marine service, etc.

Direct Current Automatic Motor Starters.

The function of an automatic motor starter is to gradually accelerate the motor up to its normal speed independently of the operator. This is generally accomplished by merely closing the pilot circuit with a knife switch, push button, float switch, or similar contact making device. An automatic starter has been developed by the Allen-Bradley Company which is very simple and durable. Other types using wire wound or grid resistance are much less substantial and are easily affected by the action of corrosive fumes, moisture, vibration, etc. This starter gives the motor a much smoother and more gradual start, since the decrease in resistance is gradual and without the characteristic steps of the ordinary resistance units.

The cycle of operation while starting the motor is as follows:

When the line switch is closed the circuit is completed through the series coil of the solenoid, the compression carbon pile resistance unit and the motor. At the same time a shunt coil is energized and the solenoid plunger drawn up, which produces pressure on the resistance units, reduces their resistance and increases the current in the motor circuit to the predetermined value at which the series coil overpowers the shunt coil sufficiently to stop the plunger from being drawn up any further. Then as the motor accelerates the current is reduced, which allows the shunt coil to still further decrease the resistance. When the motor is running at full speed the resistance unit and series coil are automatically short circuited.

A booklet has been prepared describing the starters, which are suitable for various classes of service, and giving price lists and dimensions. A copy of this booklet may be had upon application to the Allen-Bradley Company of Milwaukee.

Small Mazda Lamps with Concentrated Filaments.

The distinctive features of the concentrated filament Mazda lamps of high wattages have proved so popular that the Edison Lamp Works of the General Electric Company has developed vacuum Mazda lamps of similar appearance in the 25, 40 and 60-watt sizes. This concentrated filament construction gives greater vertical distribution of light than the regular Mazda lamps of corresponding wattages. The new lamps will, therefore, be employed where natural distribution of light downward is required. They can be used in existing sockets and fixtures.

These lamps will be made in the same sized bulbs as the corresponding regular Mazda lamps, will have the same spherical watts per candlepower efficiency and will have a rated average life of 600 hours.

Bulletin on Line Transformers.

A very interesting bulletin is now offered by the Pittsburg Transformer Co., containing a reprint of a paper read before the A. I. E. E. on "Experience with Line Transformers." This article contains several tables which should be of interest to electrical engineers dealing with transformers. This bulletin will be sent upon request to all inquirers.

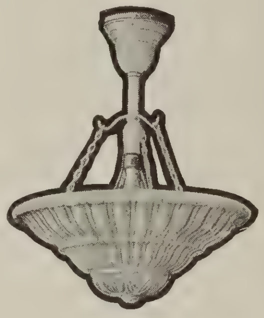
Mr. Carlton R. Mabley, who for the past five years, has been general manager of the R. I. V. Ball Bearing Co., on March 15th joined the selling organization of the S. K. F. Ball Bearing Co. The growth of the S. K. F. organization since its introduction into this country, has necessitated an addition to its forces. On account of Mr. Mabley's experience in automobile and machine manufacturing lines, his addition to the company is of note.

OKONITE
INSULATED WIRES AND CABLES

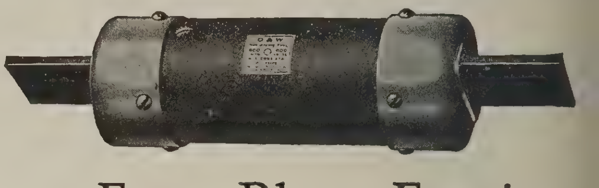
ALBERYL
GLASSWARE

ELECTRICAL

For All Classes of



The ALEXA-LITE is the last word in efficient office lighting. Ask for details.



Every Blown Fuse is An Expense

Every fuse that blows *under its rated capacity* is an *unwarranted* expense.

Many do not analyze the causes that add dollars to their fuse bills.

Defective interior construction, weak joints and imperfect alignment of blades cost fuse consumers hundreds of dollars a year.

Consider These Points in "D & W" Construction

The links are scientifically designed.

Every joint is *riveted* as well as soldered. They won't let go.

The blades are properly aligned. Excessive heating is eliminated.

All metal parts are ample and are securely fastened to the tube.

"SPECIFY D & W"
And Get More Fuse Value

A Customer Says:

"The 400-watt lamps with large base came in today and we are now enjoying a perfect office light; no dark corners, no shadows, no eye strain. Like so many other good things common today, but unknown to a previous age, we don't see how we got along without it. Will certainly make use of more ALEXA-LITES when opportunity offers."

In addition to the above, we carry a complete stock in Chicago, for
dulets, linemen's tools, pole line material, glassware, reflectors, incan-
Special car material, such as car switches, distributing boxes, switch-
If it's electrical, we are in position to furnish it.

INQUIRIES AND ORDERS

Central Electric Company

"The House of Service"

320-326 So. Fifth Avenue **Chicago**

COLUMBIA
MAZDA

CON-DULETS

"Sirocco"
MOTOR DRIVEN BLOWERS

RAILWAY
ELECTRICAL ENGINEER

**Official Journal
of the Association of Railway Electrical Engineers.**

PUBLISHED MONTHLY BY

WRAY PUBLISHING CO.
EDWARD WRAY,
President.
C. D. SPERRY.
Editor.

ADVERTISING BLDG.—123 W. MADISON ST.
CHICAGO.
Telephone, Randolph 7414.

Entered as second-class matter, August 6, 1909, at the Post Office at Chicago, Ill., under the Act of March 3, 1879.

TERMS OF SUBSCRIPTION
United States, Canada and Mexico - - - Per Year, $1.00
Foreign - - - - - - - - - - Per Year, $1.50

Table of Contents

Editorials: Page

Car Lighting Generator Lubrication.................353
The Atlantic City Convention 353
A Practical Study of Car Lighting Problems, by W. C. Gove and L. C. Porter..............................354
Measuring Amperes with an Ampere Hour Meter.......361
Coal Barge Loading Plant...........................362
Shop Motor Section 363
Principles of Alternating Current..................366
Railroad Electricians' Club 369

A. B. C. Car Lighting Course:

Setting Safety Combination Regulators in Yard.....370
Adjusting U. S. L. Stop Charge Relay in Yard.......371

Practical Stunts:

Yearly Greasing of Axle Generator Ball Bearings....372
Under Cutting Mica with Armature in Place.........372

Prize Question Box:

Life of a Storage Battery 373
General News Section 374
Association Directory 376

Car Lighting Generator Lubrication

Car lighting engineers were rather surprised a year ago to learn that car lighting generators had been very successfully operated for a period of six months without any attention whatever being paid to the ball bearings upon which the armature shaft is mounted.

This six months period of ball bearing inspection has been found entirely satisfactory and some roads have extended this period to cover a longer time, in fact one large road has decided to clean and lubricate axle generator ball bearings only once a year, this being done when the car is overhauled annually at the shop. The bearing will be given a small charge of grease at the end of the first six months and if the car is not shopped at the end of the twelve months' period the bearing will then be given another shot of grease with the grease gun.

This, it would seem, is much like the proposition of riding the willing horse too hard; for after years of bi-weekly and sometimes daily lubrication of plain bearings, we now object to giving the ball bearings proper attention semi-annually. There is a temptation to see how long the ball bearings can be operated without any attention whatever and this is very apt to lead to trouble.

Ball bearings and storage batteries are much of the same nature, they are both good and faithful servants unless you wantonly abuse them. Careless handling, neglect and abuse will quickly ruin either, whereas with reasonable care, they will both perform their service with great reliability and give long life.

Car lighting engineers should look with considerable apprehension upon the practice of extending the period of cleaning ball bearings to the annual shopping which is given to each car. This shopping interval frequently runs to eighteen months, sometimes two years, so the chances of injury to the ball bearings due to the gradual accumulation of dirt over this long period, would be great.

Under the Practical Stunts section of this issue a ball bearing of a car lighting generator is shown as it was first inspected after six months continuous operation during the winter without any attention whatever having been given the bearing. It will be noted upon referring to this illustration that the reserve grease remains in a semi-circular ring in the bearing cap some distance away from the bearing itself. During the summer months this ring of reserve grease softens so that it becomes worked uniformly throughout the bearing, as it should be. There is probably no question but that ball bearings will operate more satisfactorily if all the grease is uniformly worked through the bearing, as happens in the summer time, than to have the bearing be sparingly supplied with grease and the main body of lubricant remaining intact in the cap, as happens in the cold winter months, and as is shown in this illustration.

Granting this to be the case, undoubtedly means should be provided in order to bring this reserve grease into action in the bearing during the cold winter months. This can be done either by carefully warming the bearing head with a torch and after the grease has become thoroughly warmed, a few turns of the armature by hand will work the grease into the bearing. Another method would be to add two or three teaspoonfuls of oil some time at the beginning of the winter; this would soften the grease sufficiently to keep it plastic, even in cold weather. Care must here be taken, however, not to add too much oil, for this might make the grease thin enough to run into the generator itself.

Two grades of grease could no doubt be profitably used, a heavy grease in the summer time, and a thin grease in the winter time so as to prevent the segregation of the reserve grease in the cap.

The Atlantic City Conventions

The annual conventions of the A. R. M. M., and the M. C. B. associations will be held at Atlantic City, June 9th to 16th, as usual on Young's Million Dollar Pier, and the semi-annual convention of the Association of Railway Electric Engineers will be held June 14th, at the Hotel Denis. As in past years there will be a large and very interesting exhibit of railway equipment on the pier and much of this will be of interest to electrical men.

There are some important progress committee reports to come up this year and electrical men of the railroads should make a special effort to attend these conventions. These committees will have many questions come up for discussion so it will be well for those possible to be present and help settle any disputed points.

A Practical Study of Car Lighting Problems*

By W. C. Gove and L. C. Porter

When the plans for the new subway in New York City were being completed, it was decided that the six hundred cars should be the latest word in car construction in every detail. Many new and interesting mechanical and electrical devices, which have been described in the various technical bulletins, were decided upon for these cars. Not the least of these most up-to-date factors was the lighting of the cars. The size, interior seat arrangement, finish and construction of the cars presented many new problems to be solved in choosing a lighting system which would meet satisfactorily the following desiderata:

(1) Quantity of light; it being desirable to have an average intensity of not less than 3 foot-candles on a horizontal plane 42 in. (1.06 m.) above the floor, at 85 per cent normal voltage.
(2) General effect and appearance of lighting system with lamps lighted or extinguished.
(3) Lack of eyestrain for both seated and standing passengers, involving not only intensity and direction of light, but also glare and possible shadows cast by standing passengers on the reading matter of seated passengers.
(4) Efficiency.
(5) Installation and maintenance expense.
(6) Depreciation of equipment in service.

In order to make a thorough study of these problems a series of tests were conducted in a full-sized model car constructed for the purpose. This car was 67 ft. 3 in. (20.42 m.) over all, by 9 ft. 10 in. (3 m.) wide, by 12 ft. 3 in. (3.73 m.) high. The interior dimensions of the body used in the tests were 65 ft. (19.81 m.) long by 9 ft. (2.74 m.) wide. Fig. 5 is an exterior view of the car. The interior car finish was white enameled headlining and walls, down to the window sills. Below the sills the walls were painted grey. The floor was concrete and the seats upholstered in yellow rattan. Fig. 1 shows the interior seating arrangement and gives the general dimensions of the car.

Photometer tests were taken to supplement such data as observation of the general appearance, installation and maintenance cost figures, etc. The photometric measurements were not made with the intention of comparing the efficiency of any particular types of illuminating devices or accessories thereto; though the average intensities obtained were used in securing the relative utilization efficiencies of the various lighting systems tested.

In making the photometer tests stations were chosen 2 ft. apart in a horizontal plane 42 in. (1.06 m.) above the car floor, over one-quarter of the floor area. The entire car, however, was equipped with lighting units. Five readings were taken at each station, on a portable photometer, recalibrated before each test. In order to make one reading comparable with any other, simultaneous voltage readings were taken, as it was found to be impracticable to hold constant voltage on the lamps. Each photometer reading was corrected to normal voltage from the characteristic curves of the lamp and the five corrected readings averaged to obtain the station value. In obtaining the average intensity for the entire car, weight was given the stations in proportion to the area covered. The illumination values were also calculated for 85 per cent normal voltage, in order to see what illumination would maintain under that condition.

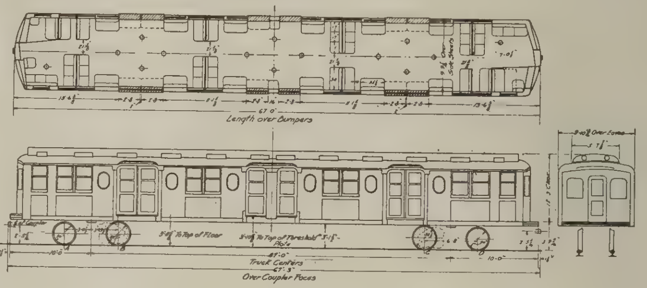


Fig. 1. Plan and Elevation of New York Municipal Railway Corporation's Subway Template Car.

The same lamps, as far as practicable, were used in the various reflector equipments. As the tests were made to find out approximately what would be the average operating condition in new cars, and not to determine the exact efficiencies of the different reflectors, figures were based on the manufacturers' data book ratings of the lamps.

It was decided before the tests started that tungsten filament lamps would be used for illuminants, the question being as to the best method of applying the lamps. Three systems of illumination were tried out, *i. e.* (a) direct lighting, (b) semi-indirect lighting, (c) totally indirect lighting. In working up various applications of these three systems, a study was made of existing installations, supplemented by many suggestions for improvement from various lighting experts and practical railway men. In order to carry on the tests the interior construction of the car was altered when necessary.

Photographs of the interior of the car were taken with the lamps burning. The exposures were timed to exactly two minutes. These photographs were intended for comparative purposes only. They have no bearing on the photometric readings, except to indicate (in a comparative way) the high and low lighting throughout the car.

The direct lighting tests made were as follows:

Direct Lighting Tests.

No 1.—The lighting units used in this test consisted of a single row of 14 6-in. opal glass reflectors (see Fig. 6) mounted along the center line of the ceiling and spaced as shown in Fig. 2. Ten of these reflectors were equipped with 56-watt clear bulb tungsten railway lamps (wired in two circuits of five lamps each in series) and the remaining four with 10-watt clear bulb tungsten emergency lamps.

The variation from even spacing shown in Fig. 2 was necessary on account of the construction of the model car, but would be corrected in the cars as finally built. The light distribution (Fig. 2) was good, though it had points of high intensity under the emergency lamps, due to the small lamp in large reflector. No bare lamp filaments were visible along the normal line of vision. The efficiency of the system was high, installation costs—on account of the single row of large units—were low, and maintenance was good, the smooth surface of the reflectors facilitating rapid cleaning. The general appearance of the lighting system in the car was pleasing (see Fig. 7) and the illumination good, averaging 5.7 foot-candles at normal and 3.2 at 85 per cent voltage, with an energy consumption of 1.03 watts per square foot. There were 5.54 effective lumens per watt and the effective utilization efficiency was 68.7 per cent. It is interesting to note that the utilization efficiency in an ordinary dark yellow trolley with similar equipment is about 30 per cent, showing the great advantage (from an efficiency-of-light-utilization standpoint) of the white enamel interior finish.

---

* A paper read at a meeting of the New York Section of the Illuminating Engineering Society, March 11, 1915.

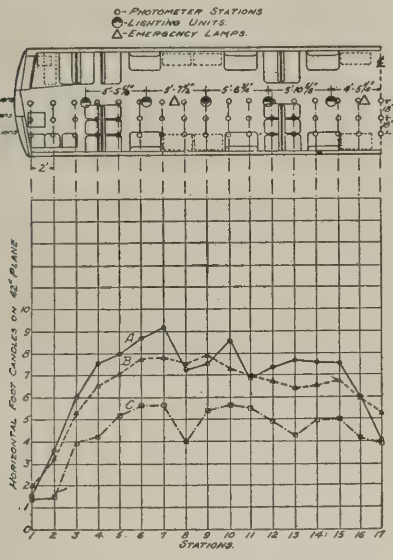


Fig. 2. Light Distribution from Ten 56-watt, 120-volt, Railway Tungsten Filament Lamps in White Glass Reflectors. Installation Shown in Fig. 6.

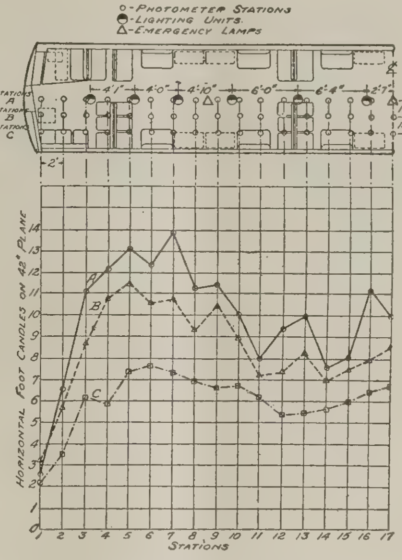


Fig. 3. Light Distribution from Twelve 80-watt, Special Opal-dipped Bulb, Turnip-shaped, Tungsten Lamps. Installation is Shown in Fig. 8.

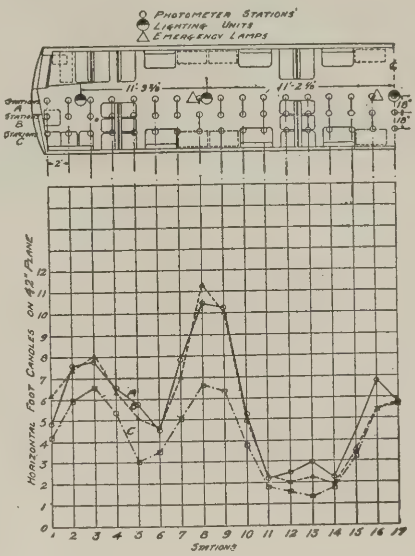


Fig. 4. Light Distribution from Five 94-watt, 120-volt Tungsten Railway Lamps in Prismatic Reflectors and Four 10-watt, 120-volt Emergency Lamps in Prismatic Reflectors. Installation Not Shown.

No. 2.—The second direct lighting test was similar to the first, except that clear prismatic reflectors were used. The change of reflectors raised the average foot-candle intensity to 6.1 at normal and 3.4 at 85 per cent voltage. The effective lumens per watt were increased to 5.90 and the utilization efficiency to 73.2 per cent. The maintenance of this equipment would be slightly higher than with the glass used in the aforementioned test, due to cleaning the prismatic glass. There was also a little more glare, though not an objectionable amount. The choice between these two reflectors, therefore, is largely one of esthetic taste.

No. 3.—In the third direct lighting test 5 94-watt clear tungsten filament railway lamps, equipped with clear prismatic reflectors were located in a single row down the center line of the ceiling. Four 10-watt tungsten emergency lamps in clear prismatic reflectors were located between these. The resultant average intensity in the car body was good, but due to the relatively low hanging height and wide spacing of the units the distribution was very uneven (see Fig. 4). The installation and maintenance of the system would be low, on account of the small number of large units to install and clean. The average foot-candles obtained were 5.0 at normal and 2.8 at 85 per cent voltage. The energy consumption was 0.87 watt per square foot; effective lumens per watt 5.75; and effective utilization efficiency 71.5 per cent.

No direct lighting tests were made with lighting units located on the half decks. Previous experience and tests had shown that center-deck direct lighting may produce perfectly satisfactory illumination, free from sharp shadows and glare. It was felt that the possible gain of a few per cent in efficiency with the half-deck lighting did not warrant the additional installation and maintenance expense (due to a larger number of smaller units to install and clean) accompanying this system of lighting.

Semi-Indirect Lighting Tests.

No. 1.—A very interesting method of lighting was used in the first test. Twelve special 80-watt 95-volt turnip-shaped tungsten lamps, opal dipped over the tip half, were installed down the center line of the ceiling. Each lamp was suspended by an inverted white enameled cone, shown in Fig. 8. Three 10-watt tungsten emergency lamps were also used in small rosettes. The 80-watt lamps were connected six in series. All of the filament of the 80-watt lamps was located below the center of the bulb; hence, none of it was in the line of vision. The opal on the lower half of the bulb served a double purpose, i. e., to protect the passengers' eyes from the glare of the bare filament and also to reflect the light up to the ceiling. The particular advantage of this system of lighting was that it eliminated the necessity of reflectors, special holders and other accessory equipment; thus lowering both installation and maintenance costs. The illumination was fairly uniform (Fig. 3), though the uneven spacing necessitated by the car construction made it unnecessarily high at the center. As the entrance and exit doors were located here, however, this was no great objection. The average intensity was 7.7 foot-candles at normal and 5.1 at 85 per cent voltage.

The energy consumption was 1.69 watts per square foot, the effective lumens per watt 4.65, and the utilization efficiency 58.4 per cent. The appearance of the car lighted was pleasing. The lamps, being located on the center line of the car, did not interfere with the clear reading of advertising signs located along the sides.

No. 2.—In the second semi-indirect lighting test a novel equipment was used (Fig. 9). Ten 56-watt clear tungsten railway lamps were located on the center line of the ceiling, supplemented by 4 10-watt tungsten emergency lamps. Six inches (15.2 cm.) below the ceiling and extending the entire length of the car, was suspended a reflector consisting of a white enameled board 11 in. (28 cm.) wide, convex on a 16-in. (0.4 m.) radius. The bowls of the 56-watt lamps extended through holes cut in this reflector. Under each hole was fastened a white glass dish to diffuse the glare of the bare lamp filament. The spacing of the lamps is shown in Fig. 13. The plan in using this combination was to utilize as much as possible of the direct light from the lamp, to illuminate the advertising signs; the indirect light to give even distribution and the direct light to brighten up the under side of the reflectors. Distribution curves from this equipment are shown in Fig. 13. The light distribution was good, but the intensity low, averaging 3.9 foot-candles at normal and 2.2 at 85 per cent voltage. The watts per square foot were 1.03; effective lumens per watt 3.81; and the effective utilization efficiency was 47.2 per cent. The resultant illumination was pleasant, but the appearance of the lighting equipment was rather crude, suggesting a watering trough down the center of the car. It was a curious fact that while both sides of the reflector and the ceiling were painted alike, the under side of the reflector appeared grey, due to the lower intensity of light on it.

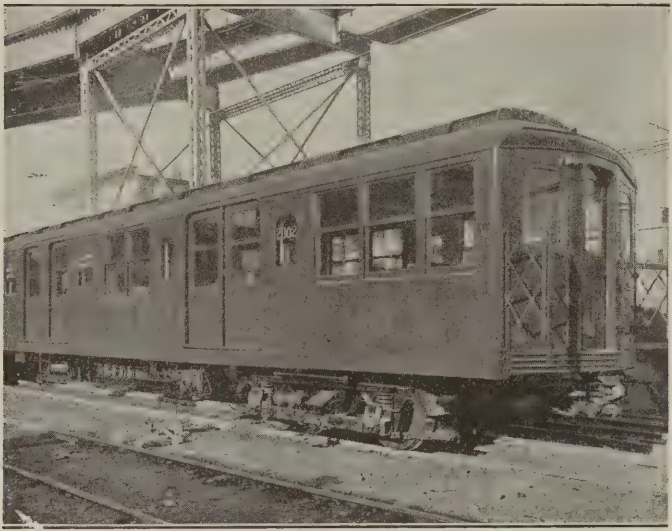


Fig. 5. Outside View of New York Municipal Corporation's Subway Car.

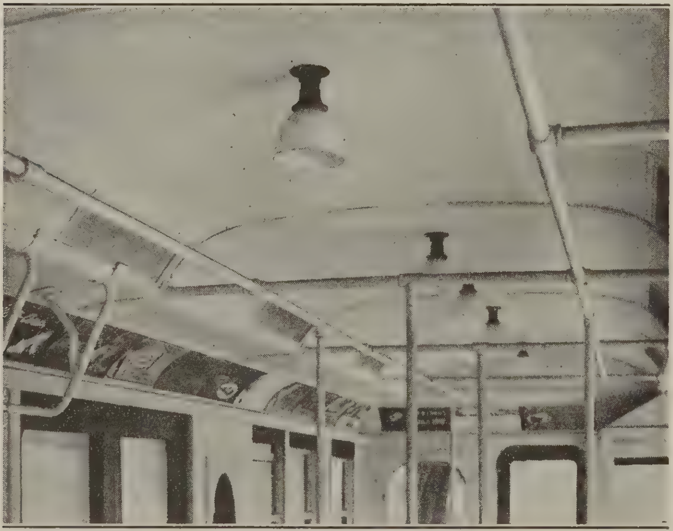


Fig. 6. Showing Installation of 56-watt Railway Tungsten Filament Lamps in White Glass Reflectors.

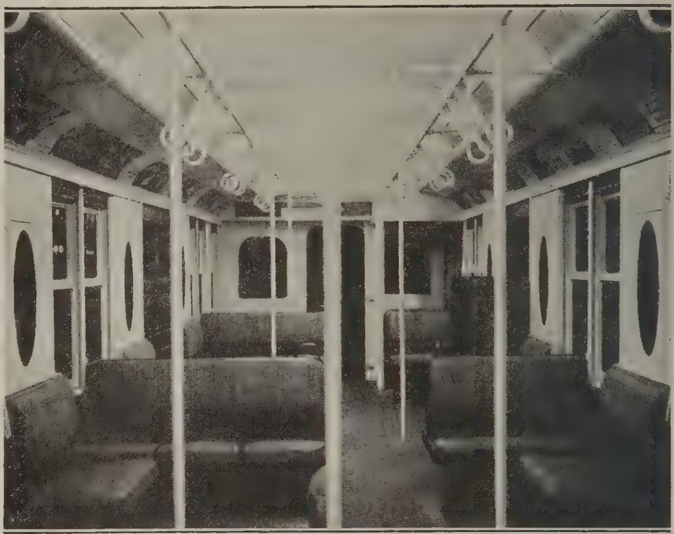


Fig. 7. Lighting Effect of Installation Same as Fig. 6.

Another test was conducted on this same equipment with the interior finish of the car silver grey instead of white. This change lowered the effective utilization efficiency about 10 per cent.

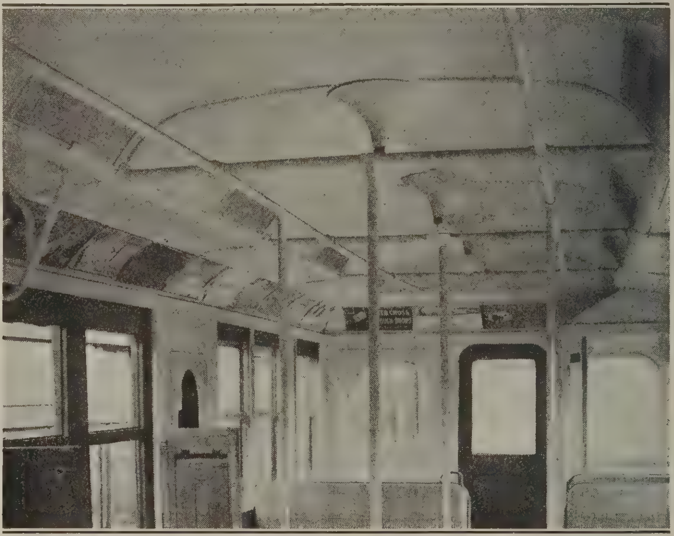


Fig. 8. Installation of 12 Special 80-watt, 95-volt Turnip-shaped Opal-dipped Bulb, Tungsten Filament Lamps, Suspended Without Reflectors from White Enameled Cone-shaped Fixtures.

The next semi-indirect equipment tested consisted of 10 94-watt tungsten railway lamps equipped with 5 13-in. (33 cm.) white glass bowls, mounted down the center line of the ceiling. There were 2 94-watt lamps and 1 10-watt emergency lamp in each bowl.

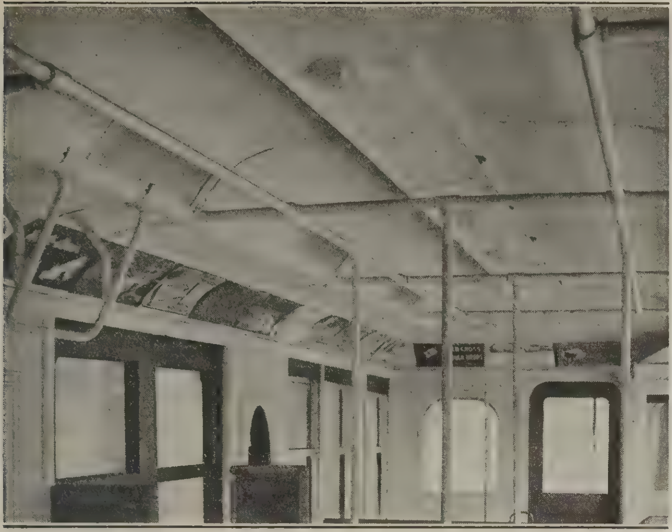


Fig. 9. Installation of 56-watt Tungsten Filament Railway Lamps in Special Convex Reflectors.

(See Fig. 10.) The bowls were hinged, allowing of lowering for cleaning and lamp replacement. The bowls were suspended with their tops located 12 in. below the center of the ceiling. The illumination from this system was very uneven, being high directly under the units and low between them (see Fig. 14). The average intensity was 5.7 and 3.2 foot-candles at normal and 85 per cent voltage, respectively; watts per square foot 1.69; effective lumens per watt 3.36; and effective utilization efficiency 41.5 per cent.

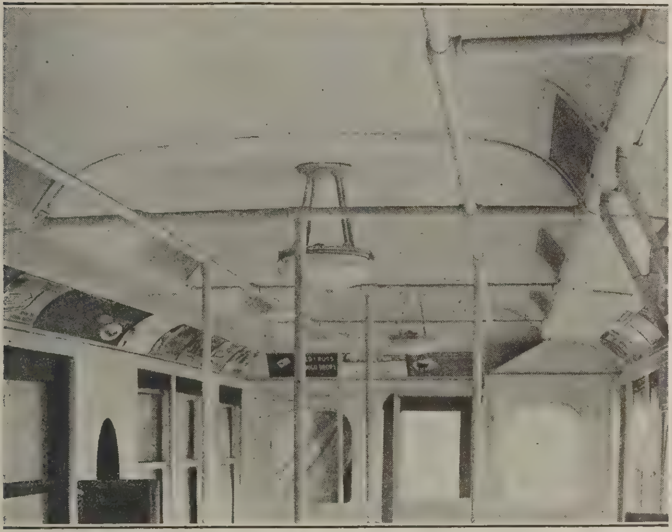


Fig. 10. Semi-indirect Lighting. Each Bowl Contains Two 94-watt Tungsten Filament Railway Lamps and One 10-watt Tungsten Emergency Lamp.

In order to determine the effect of the shape of the ceiling on the light distribution, a special headlining consisting of a white enameled insert, having a 3 ft. (0.91 m.) span on an 18 in. (0.45 m.) radius, was inserted and the test repeated. Fig. 11 shows the appearance of the insert and illumination effect. This resulted in raising the average foot-candles to 6.1 and 3.4 at normal and 85 per cent voltage, respectively; effective lumens per watt to 3.62; and the utilization efficiency to 44.7 per cent. The distribution curves of this equipment are shown in Fig. 15.

The insert was then removed and the test repeated with a different spacing of the units. This resulted in a little improvement in distribution. The principal trouble with this installation was that the headroom in the car was not sufficient to allow the lighting units to be hung the proper distance below the ceiling.

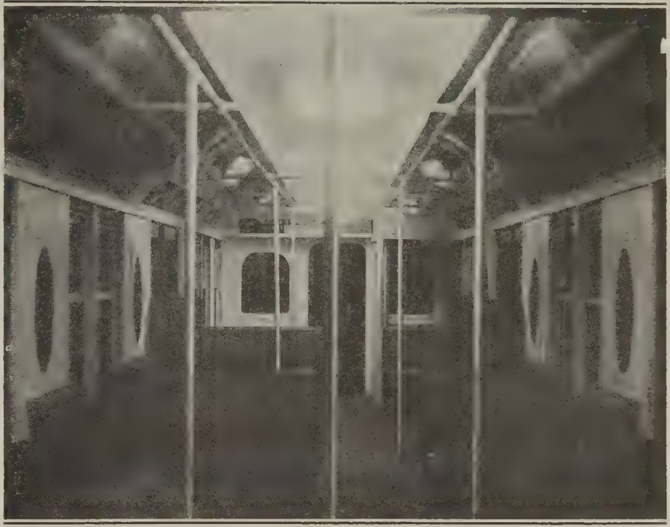


Fig. 11. Lighting Effect from a Semi-indirect Installation with Special Ceiling Insert.

The next equipment tested required special reflecting devices. Ten 56-watt clear tungsten railway lamps were located in a single line down the center of the ceiling, with 5 10-watt all-frosted emergency lamps in rosettes between them. Each 56-watt lamp was equipped with a screen made from a circular piece of glass bent over a cylinder (Fig. 12). This resulted in a screen 11 in. (27.9 cm.) long by 8 in. (20.3 cm.) wide by 3 in. (7.62 cm.) deep. When these screens were hung beneath the lamps with their open ends towards the sides of the car, it was impossible to see the lamp filaments from any part of the passenger car body; at the same time the direct light from a considerable portion of the lamp fell on the ceiling and reached the reading plane with but one reflection, making the system fairly efficient. The distribution lengthwise of the car was even, though the outboard seats received considerably less light than the center aisle of the car (Fig. 20). The average intensity was 4.8 and 2.7 foot-candles at normal and 85 per cent voltage; the energy consumption 1.04 watts per

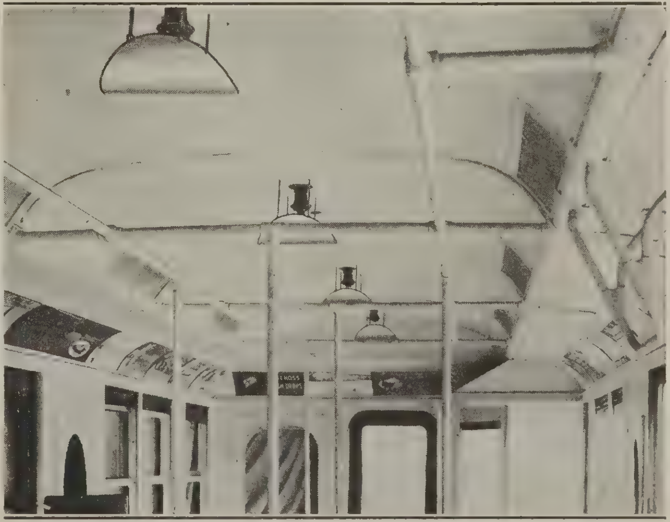


Fig. 12. Showing Installation of Tungsten Filament Lamps and Special Curved White Glass Screens.

square foot; effective lumens per watt 4.63; and effective utilization efficiency 57.6 per cent. The chief advantage of this equipment was the ease with which the reflectors could be cleaned. The appearance of the car lighted was rather pleasing.

Totally Indirect Tests.

No. 1.—The first totally indirect equipment tried consisted of 8 special indirect fixtures, these being white porcelain enameled on steel, 15½-in. (39 cm.) in diameter and 5½ in. (16 cm.) deep (Fig. 16). Each fixture contained 3 36-watt tungsten lamps mounted vertically. The fixtures were hung in a single row down the center line of the ceiling, the tops of the reflectors being 13 in. (33 cm.) below the ceiling. The spacing of the units is shown on Fig. 21. The resultant illumination was uniform and of fairly good intensity, averaging 5.1 and 3.2 foot-candles at normal and 85 per cent voltage, for an energy consumption of 1.47 watts per square foot. The effective lumens per watt were 3.43 and the effective utilization efficiency was 46.3 per cent. The chief drawback of these fixtures was their liability to catch and collect much dirt, thus materially reducing their efficiency; also, to obtain good distribution it was necessary to hang them so low that they might be in the way of tall passengers.

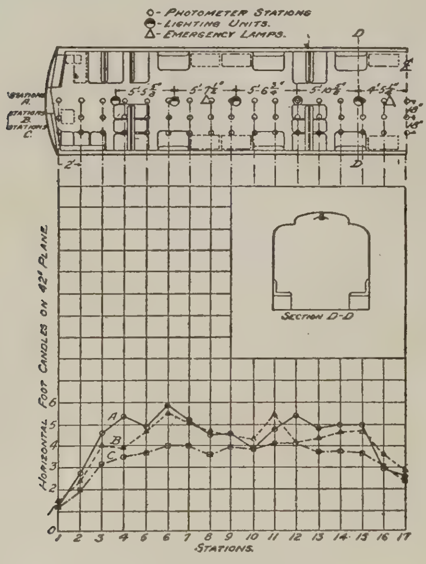


Fig. 13. Light Distribution from a Semi-indirect Installation Consisting of Ten 56-watt Tungsten Railway Lamps in Special Convex Reflector and Four 10-watt Emergency Lamps. Installation Shown in Fig. 9.

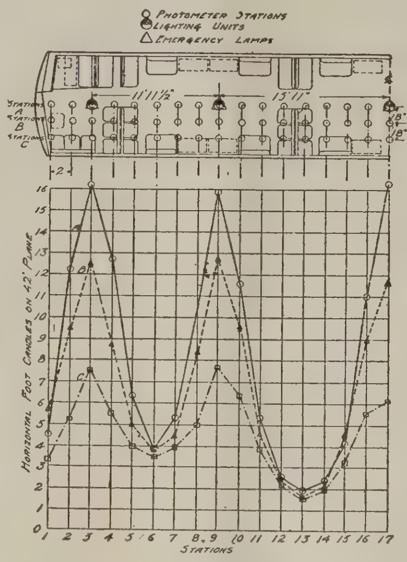


Fig. 14. Light Distribution from an Installation of Five Semi-indirect Units. Installation Shown in Fig. 10.

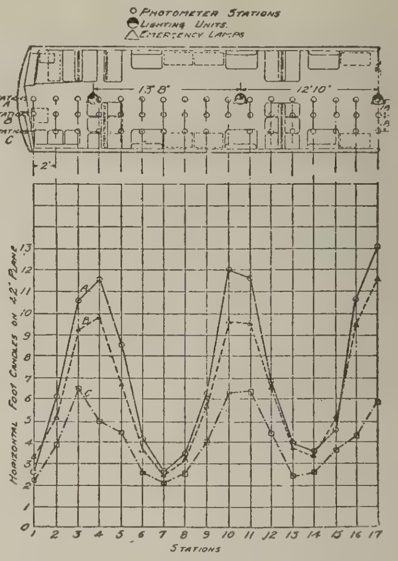


Fig. 15. Light Distribution from Five Semi-indirect Units and Ceiling Insert. Installations Shown in Fig. 11.

No. 2.—In order to get away from a low fixture in the center line of the car, the next equipment tested consisted of 20 36-watt tungsten railway lamps in indirect reflectors. These were mounted in two rows of ten each on the sides of the car, just above the deck sill between the ventilators, as shown in Fig. 17. Five 10-watt frosted lamps in rosettes were mounted on the ceiling for emergency lamps. The 36-watt lamps were mounted horizontally with their centers 7 ft. 4 in. (2.25 cm.) above the floor. The spacing of the lighting units and the distribution therefrom is shown in Fig. 22. The resultant illumination was of low intensity, averaging 3.5 and 2.2 foot-candles at normal and 85 per cent voltage. The wattage consumption was 1.32 per square foot; effective lumens per watt were 2.67; and effective utilization efficiency was 36.3 per cent. The main objection to this system was the problem of keeping the reflectors clean.

No. 3.—The last test was made on 12 94-watt tungsten railway lamps in indirect reflectors and 5 10-watt emergency lamps in rosettes, located down the center line of the ceiling. In order to get maximum headroom for these reflectors and still have them out of the way of passengers, special inverted cone-shaped containers for the reflectors were built into the stanchions along the center line of the car (Fig. 18). Unfortunately the construction of the car necessitated spacing the units rather far apart, so that uneven illumination resulted. In addition to the bowls, smaller inverted bowls were mounted on the horizontal grab rails, at points shown in Fig. 23. Each of these contained 1 94-watt tungsten lamp, making a total of 12 94-watt and 5 10-watt lamps in the car. The average foot-candles were 8.5 and 4.7 at normal and 85 per cent voltage; watts per square foot 2.01; effective lumens per watt 4.21; and the utilization efficiency was 53.4 per cent. Considerable difficulty would be experienced in keeping this equipment clean and free from refuse.

The tables in the appendix gives general summary of the tests.

Important Considerations.

In studying the tests to choose the final method of lighting, the following considerations were carefully weighed:

General Effect and Appearance.—The general effect and appearance of each system under test were judged by comparison with present methods (in general) of car lighting for similar service, *i. e.*, with the use of tungsten lamps but without reflectors. Under this item was also considered the effect of the distribution of light on the various parts of the car.

Lack of Eyestrain.—In comparing the various systems tested, the effect of the light on the eyes was particularly noted by a large number of observers.

Ease in Reading for Seated and Standing Passengers.—In comparing the three methods of lighting—direct, indirect and semi-indirect—particular attention was given to the possible shadows thrown on reading matter of seated passengers, by passengers standing in a crowded car. In some cases it was found that passengers could obtain proper light in any position; in others it was necessary for them to move in their seats, often to uncomfortable positions, to obtain proper light.

Efficiency of System.—The efficiencies of the various lighting systems tested differed widely. In some cases this was largely due to the type of reflector used; in others to the position of the reflector, shape of the ceiling, etc. In several tests it was evident that improvement could be made by changes. Should any one system meet with particular favor in all other respects, it was considered probable the efficiency could be raised by a more detailed study.

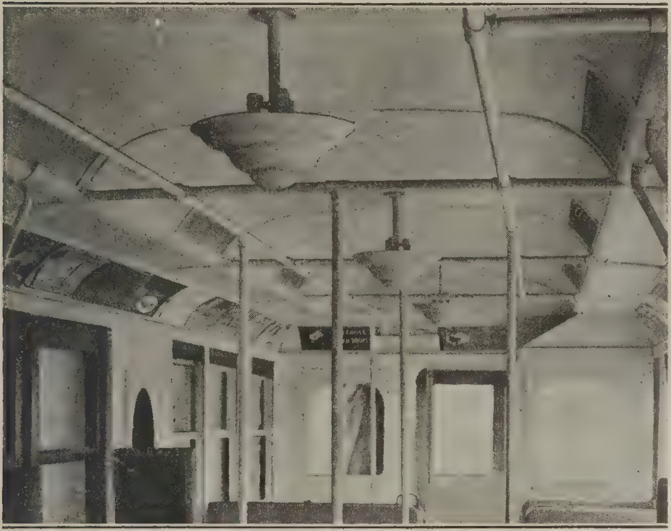


Fig. 16. Installation of Special Indirect Fixtures. Each Fixture Contains Three 36-watt Tungsten Filament Railway Lamps. Light Distribution Shown in Fig. 15.

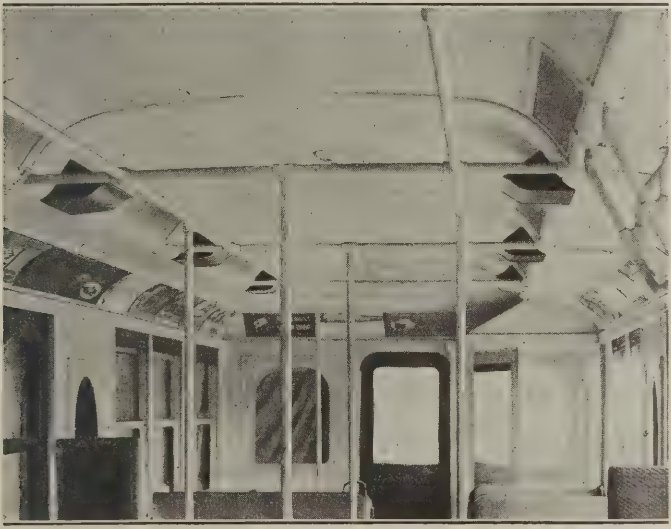


Fig. 17. Special Installation of Indirect Lighting. Reflectors Set in Covers, Ten on Each Side. Ceiling Rosettes for Emergency Lighting.

Maintenance.—The question of maintenance was serious. Some of the most desirable arrangements of reflectors and lights were handicapped by the dust problem. With a large number of small units this difficulty increases. Various methods of keeping reflectors and ceiling clean were considered.

Power Consumption.—In order to secure a reasonable operating cost, low power consumption was considered one of the important factors. The indirect system of lighting required considerable more power than the direct, while the semi-indirect came between these two.

Depreciation.—The relative loss of reflecting power, due to accumulation of dust on the various types of reflectors, was also given careful consideration.

Emergency Lighting.—It was decided that sufficient light would be obtained from the emergency lights to permit clearly distinguishing people and various objects in the car with main lamps extinguished.

Results.

A thorough study of all these conditions finally led to the adoption of a single line of 15 56-watt bowl-frosted tungsten railway lamps down the center line of the ceiling, equipped with reflectors as shown in Fig. 19, supplemented by 6 10-watt all-frosted round bulb tungsten emergency lamps. This system was chosen as the one containing the highest percentage of the desirable factors—satisfactory illumination, low power consumption, low maintenance and upkeep and pleasing appearance with the lamps both lighted and extinguished.

The spacing of the reflectors was arranged to be symmetrical. One unit was placed on each end bulk-

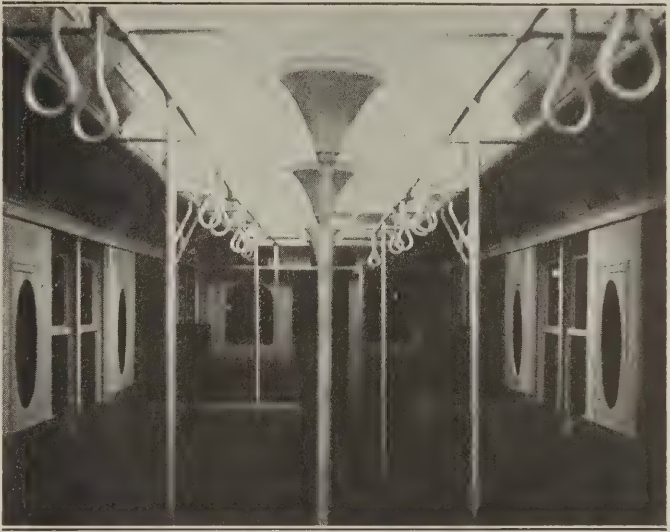


Fig. 18. Indirect Lighting from Units on Stanchions and Grab Rails.

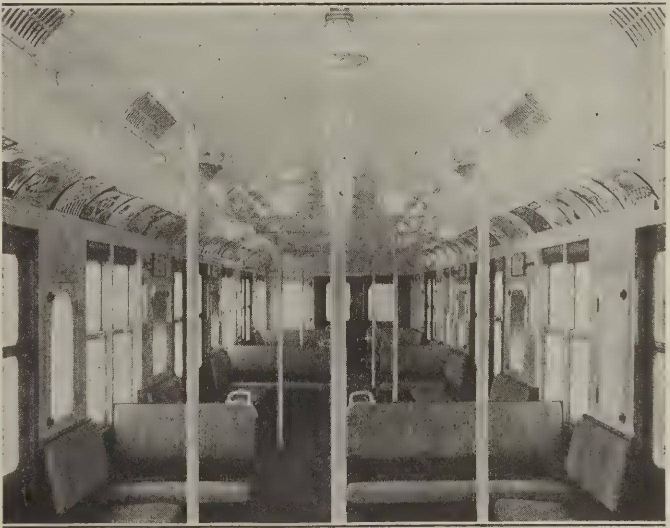


Fig. 19. Equipment Finally Adopted, Consisting of Fifteen 56-watt Bowl-frosted Tungsten Filament Railway Lamps in White Glass Reflectors Supplemented by Six 10-watt Round Bulb, All-frosted Tungsten Filament Lamps for Emergency Lighting.

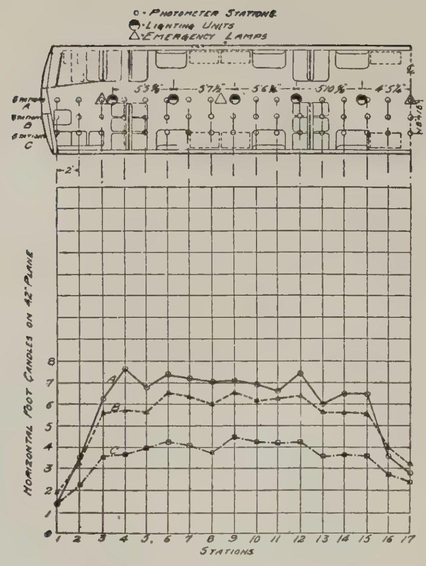


Fig. 20. Light from Ten 56-watt Tungsten Railway Lamps in Curved Screens, and Five 10-watt All Frosted Emergency Lamps Set in Ceiling Rosettes. Installation Shown in Fig. 12.

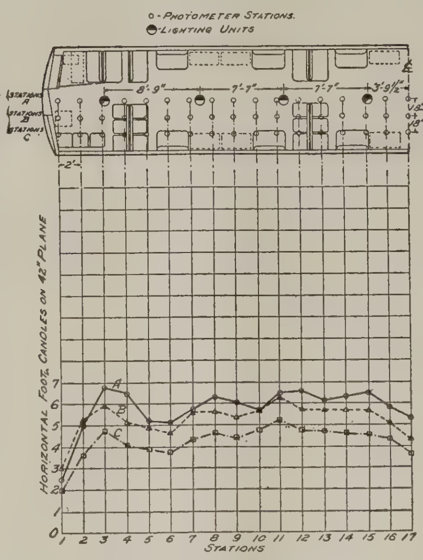


Fig. 21. Light Distribution from Eight Special Indirect Units. Installation Shown in Fig. 16.

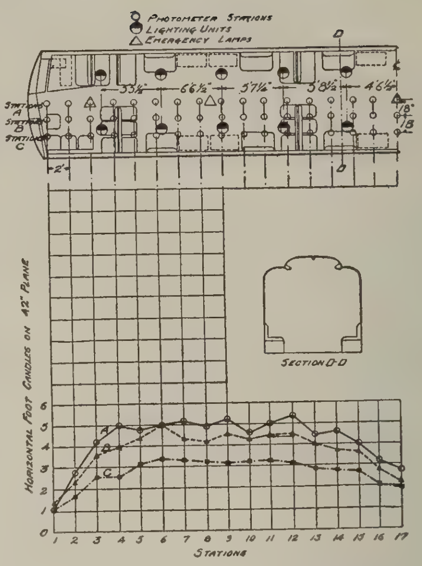


Fig. 22. Light Distribution Curves Obtained from the Special Installation of Indirect Illumination Shown in Fig. 17.

head of the car to bring up the illumination at these points.

Fig. 19 shows the interior of the car as finally equipped. The illumination averaged 5.94 foot-candles at normal and 3.85 at 85 per cent voltage. The energy consumption was 1.44 watts per square foot; effective lumens per watt 4.14; and the utilization efficiency 50.6 per cent.

It was interesting to note that the low intensities of illumination, at stations 7 and 17 (Fig. 24), are opposite the entrance doors, which are dark green, in comparison to the white finish between doors.

On the whole, the illumination is remarkably soft, even and pleasing. It is not possible to note any unevenness with the naked eye. The use of bowl-frosted lamps lowers the efficiency a little, but also eliminates glare, even when looking directly up at the lamp.

Block signal lights are located in the cab, *i. e.*, instead of having the signals aside of or above the track, as is usual; the signal is located in the car in front of and slightly to the right of the controller. The signal consists of three lights—red, green and yellow—each containing a 32-volt tungsten filament lamp of about 10 watts capacity. It is planned to use double filaments in these lamps, so that when one fails the other will still be in operation. If the signal is set to stop and is not obeyed, within a certain distance, a warning whistle blows near the motorman, and if the signal remains unheeded a certain further distance, the brakes are automatically set. Coupling two or more cars together also cuts out the signals in the cabs other than the two on the ends of the train. A small 32-volt ½-candlepower tubular carbon lamp is also installed over each air gage.

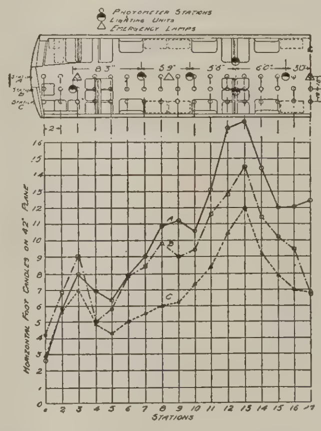


Fig. 23. Light Distribution Curves Obtained from the System of Indirect Illumination Shown on Fig. 18. Construction of Car Necessitated Spacing Units Rather Far Apart.

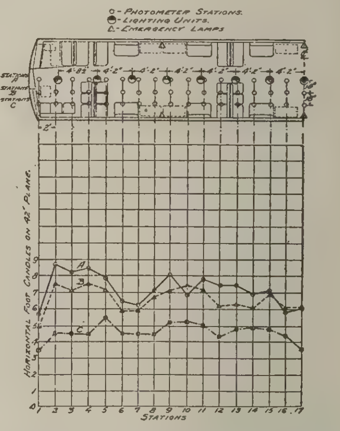


Fig. 24. Light Distribution from Fifteen 56-watt Bowl-frosted Railway Tungsten Lamps in White Glass, Reflectors, and Six 10-watt Frosted Emergency in Rosettes Over Side Doors. Installation Shown in Fig. 19. Equipment Finally Adopted.

Test Data Condensed.

Test No.	Lamps	Reflectors	Foot-candles[1] Normal voltage	Foot-candles[1] 85 per cent. voltage	Total watts	W/sq. ft.[2]	L/W[3]	Per cent. efficiency[4]
1	10 56-watt	6-in. Sudan No. 01225	5.685	3.157	600	1.03	5.540	68.7
2	10 56-watt	Holophane XI-40	6.056	3.350	600	1.03	5.905	73.2
3	5 94-watt	Holophane XE-100	5.020	2.780	510	0.871	5.758	71.5
4	12 80-watt	None	7.695	5.144	990	1.692	4.649	58.4
5	10 56-watt	Doric dishes	3.908	2.170	600	1.03	3.810	47.2
6	10 94-watt	Pyro No. 1209	5.688	3.165	990	1.692	3.361	41.5
7	10 94-watt	Pyro No. 1209 (ceiling insert)	6.133	3.383	990	1.692	3.624	44.7
8	10 94-watt	Pyro No. 1209 (different spacing)	5.554	3.059	990	1.692	3.282	40.5
9	10 56-watt	Moonstone screens	4.834	2.680	610	1.042	4.635	57.6
10	24 36-watt	Alexolite	5.060	3.210	864	1.477	3.426	46.3
11	20 36-watt	E-60 National X-Ray in coves	3.514	2.230	770	1.316	2.670	36.3
12	12 94-watt	E-100 National X-Ray	8.463	4.700	1178	2.013	4.206	53.4
13	15 56-watt bowl-frosted Mazda[5]	6-in. Sudan No. 01225	5.94	3.85	840	1.44	4.14	50.6

[1] Average effective foot-candles on a horizontal plane 42 inches above the floor, in car body.

[2] Watts per square foot.

[3] Effective lumens per watt.

[4] Effective utilization efficiency.

[5] Equipment finally adopted.

Measuring Amperes with an Ampere Hour Meter

The ampere hour meter is now coming into such general use in railway car lighting service that the following table which shows how this meter may be used as an ammeter will be of interest.

The ampere hour meter which is most generally used is what is known as a "60 ampere meter;" that is, the full load current of the meter is 60 amperes. The meter is built to stand an overload, however, of at least 50 per cent continuously and 100 per cent for 30 minutes or more without injury. One revolution of the meter disc represents 216 ampere seconds; that is, theoretically, one ampere flowing for 216 seconds would cause the disc to make one revolution, or 216 amperes flowing for one second would also cause the disc to make exactly one revolution. Intermediate values have been computed and are given in the following table:

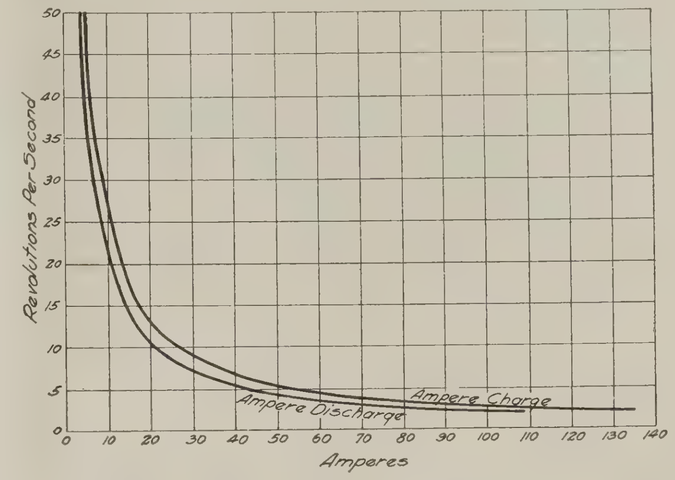
Seconds per Revolution	Amperes Discharge	Amperes Charge
2	108	135
3	72	90
3.6	60	75
4	54	67
5	43	54
7	31	39
6	36	45
8	27	34
9	24	30
10	22	27
12	18	22
14	15	19
16	13	16
18	12	15
20	11	13
25	9	11
30	7	9
35	6	7.5
40	5	6
50	4 approximately	5 approximately
1 min.	3.6 approximately	4.5 approximately
1 min. 12 sec.	3.0 approximately	3.9 approximately
1 min. 50 sec.	2.0 approximately	2.5 approximately
3 min. 36 sec.	1.0 approximately	1.2 approximately

In making use of this table for determining battery current flow the car lighting inspector must first find out whether the current is flowing in a charge or discharge direction. This will be noted by the direction in which the disc revolves; he will then note the number of seconds required to make one revolution. If the disc is revolving at a speed faster than one revolution in 10 seconds it will be better to note the number of seconds for 5 or 10 revolutions and divide to obtain the exact number of seconds per revolution.

As an example, say the meter is found to revolve 10 times in 45 seconds with the current flowing on discharge; this requires 4½ seconds for each revolution. Upon referring to the first column of the table, opposite 4 seconds per revolution, we find in the second column 54 amperes, while for 5 seconds per revolution, we find in the second column that this represents 43 amperes. Therefore, 4½ seconds per revolution would represent a current flow of about half way between these, or 48 amperes. If this current had been flowing in a charging direction it would have represented a current 25 per cent greater than this, as shown in the third column, if meter is set to give 25 per cent overcharge.

As another example, assume that the battery is on charge and the inspector notes that it requires 20 seconds to make one complete revolution. Upon referring to the table we locate 20 seconds per revolution in the first column and opposite this in the third column, under amperes charge, we find 13, therefore, with the disc revolving at a speed of one revolution in 20 seconds, there is a charging current of 13 amperes flowing.

These figures are all based on using the 60 ampere meter. If the 40 ampere meter is used the values for amperes charge and discharge will only be two-thirds of those given in the table. As an example, assume that with a 40 ampere meter the inspector finds that the disc makes one revolution in 5 seconds with the battery on discharge. Upon referring to the first column of the table opposite 5 seconds per revolution, we find in the second column, under amperes discharge, 43. Since these figures are based on a 60 ampere meter and 40 ampere meter is used in this case, the current will be only two-thirds of this value, 43, or 29 amperes.



Curve Showing Relation Between Revolutions Per Second and Current Flowing.

These figures will not be reliable where the current flow varies to any extent during the time of counting seconds per revolution. It will, however, give the average current during the time of test. The meter is adjusted to record true ampere hours on discharge and the resistor type meters are usually set to automatically run 20 per cent slower on charge, which means that an overcharge of 25 per cent in ampere hours will be provided. The current rate on charge, for the same speed of revolution will be 25 per cent greater than that on discharge, as shown in the accompanying table. If the meter is set for some other percentage than 20 per cent slow on charge, which represents 25 per cent overcharge and 25 per cent increase in ampere current flow, this will have to be kept in mind in determining the amperes current flowing on charge. The discharge current flow, however, will be according to the table in all cases, as the meter is built so as to record true ampere hours, whatever the percentage of overcharge may happen to be.

Coal Barge Loading Plant

By H. S. Shimizu

A coal barge loading plant has just been completed for the Illinois Central R. R. at Harahan Incline, about 10 miles north of New Orleans, La. This plant was built to cope with the enormous demand for fuel, which is expected to result from the coastwise shipping that will pass through the Panama Canal now opened to the public.

Considerable thought and study was given by the officials of the Illinois Central in determining the type of plant that would be most efficient, and one that would meet the somewhat peculiar requirements of this installation. The belt conveyor system, that will be described in this article, was the result of this investigation.

The new plant is built on the east bank of the Mississippi River at a point known as Harahan Incline, where the Texas & Pacific and Illinois Central trains are transferred across the Mississippi River on large barges. The Mississippi River at this point rises 20 ft. 6 in. above low water during high tide—the normal water level being 5 ft. above low water. Coupled with this tidal variation the nature of the river prevents the tracks from being brought nearer than 200 ft. from the cluster wall, where the barges are stationed for receiving coal. The conveying apparatus, besides being of considerable length, must be able to deliver coal into barges at a varying height.

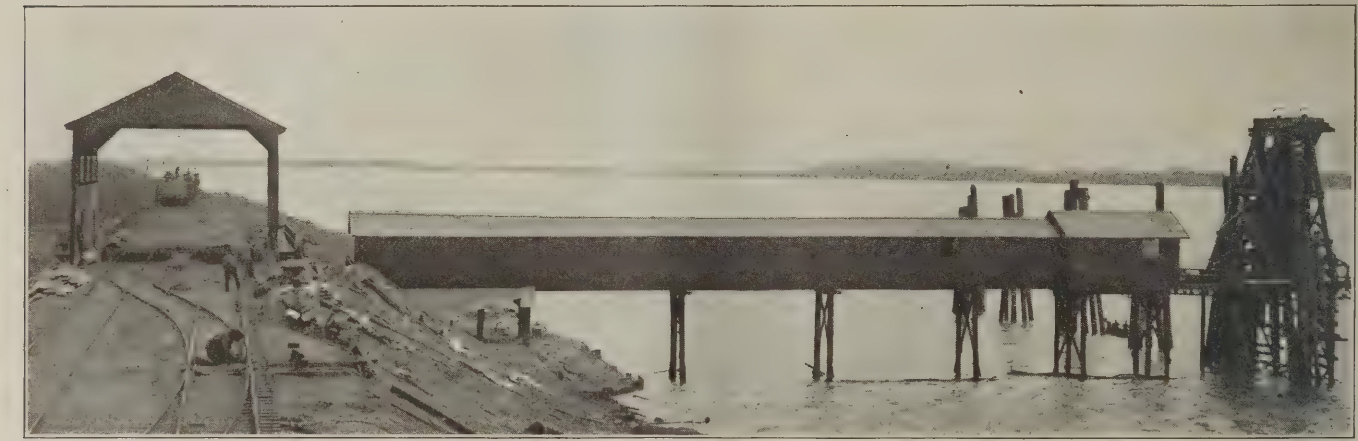


Fig. 1. A General View of the Coal Loading Plant. At Extreme Left is Shed Where Cars Are Emptied. In Center is Shown Housing for the Conveyor, on the Cluster of Piles at the Right the Conveyor Hoisting Apparatus is Shown. The Operator's Cabin is at the Extreme Right of the Housing.

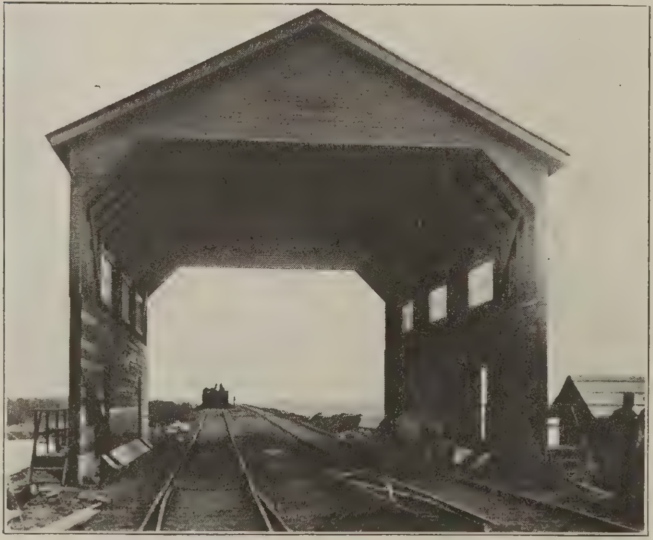


Fig. 2. Coal Loading Shed. Coal is Dumped Into Hoppers Below Track from Whence it is Removed by the Belt Conveyor.

The Illinois Central R. R. Co. have installed two inclined receiving tracks 15 ft. centers, spanning over the reinforced concrete receiving hopper, which is 38 ft. in length and 28 ft. in width, the base of the rails being fixed at 8 ft. above high water. Under the hopper is installed a large reciprocating feeder, mine run coal being fed through an opening 5 ft. by 5 ft. in dimension. The coal is then loaded onto a 36 in. belt conveyor running in a concrete tunnel, which is on an incline of 18 deg. for part of its length. This conveyor, after leaving the tunnel, travels horizontally 3 ft. above the high water until it reaches a point 30 ft. from the cluster piles, then continues on a pivot hinged steel loading boom 50 ft. long, bring the discharge end of the conveyor 20 ft. beyond the piles. The boom is adjusted to load barges at any stage of water level between low and high water, viz., 20 ft. 6 in. variation.

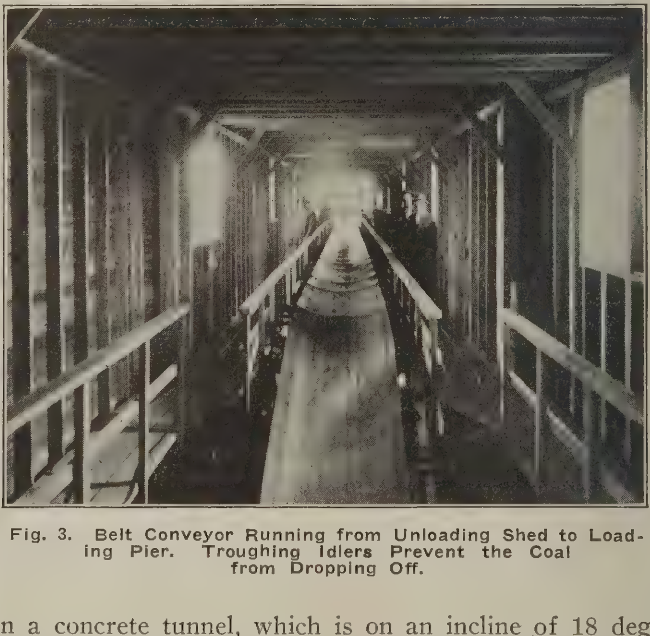


Fig. 3. Belt Conveyor Running from Unloading Shed to Loading Pier. Troughing Idlers Prevent the Coal from Dropping Off.

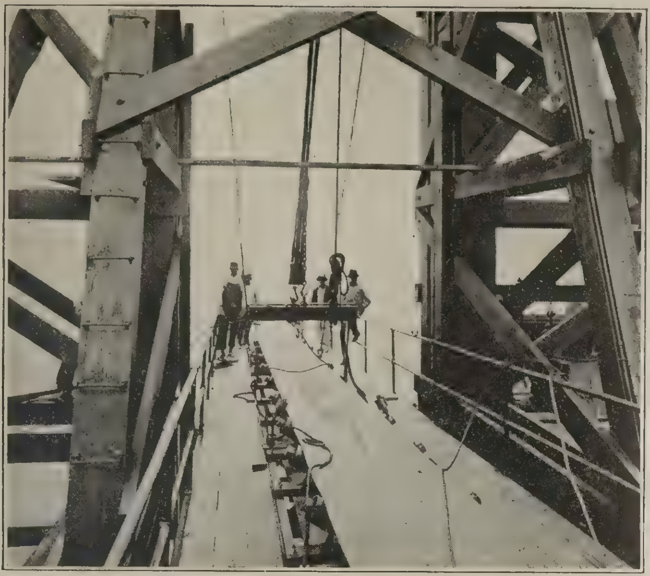


Fig. 4. Adjustable Platform With Belt Conveyor Mounted in Position. Coal Dumps Directly from Belt Conveyor Into the Vessel, Obviating All Handling of Coal by Hand.

The conveyor is designed to carry coal at the rate of 300 tons per hour for run of mine coal. It consists of a 6-ply Ajax conveyor belt, stitched longitudinally on 1 in. centers and covered with ⅛ in. extra rubber in the center. The conveyor is driven by a 35 h. p. 220 volt, 3-phase, 60 cycle 8-pole General Electric induction motor, running at a speed of 900 r. p. m. and direct connected to a countershaft with a forged steel spur pinion. The countershaft, in turn, drives, by means of spur gears and two head shafts, which are geared together with spur gears of equal size, so that they will rotate in the opposite direction. The object being to have an ample contact of belt around the head pulleys.

The reciprocating feeder, which feeds the coal from the hopper onto the conveying belt, is driven from the foot end of the conveyor. The conveyor machinery is of the heaviest type, being continuous 5-pulley troughing idlers best adapted for the purpose.

The boom is operated by a 3-ton Shepard Electric hoist, using 220 volt, 3-phase, 60 cycle alternating current with a maximum lift of 18 ft. and a hoisting speed of 13 ft. per minute. This electric hoist is designed with a squirrel cage motor, waterproofed for outdoor service, and the controller is located in the operator's house for remote control. The hoist is located on the top of the tower, which is built on the cluster piles, and directly above the hoisting point of the boom. The operator's house is just behind the hinged point of the boom, and amply large to accommodate rhw. 24 h. p. motor, driving machinery for the conveyor and the controller for the boom hoist, as well as the electric car puller for controlling position of the barges. Electric power is transmitted from the power station located about two miles north of the plant.

This plant was constructed under the supervision of Mr. Maro Johnson, Engineer of Bridges and Buildings of the Illinois Central Railroad Co., and was designed by the Roberts & Schaefer Co., engineers and contractors, of Chicago.

Shop Motor Section

Simplified Three Phase Windings

J. H. Wickman

In all the diagrams which we have described heretofore two coils have been placed in each slot. This form of winding is generally used but in some classes of three-phase alternating current machines it is often convenient to use but one coil per slot. Such a winding is shown in Fig. 8, which is a group winding with full pitch, having 4 poles, 48 slots and 1 coil per slot, 2 coils per group, each coil having a throw of 1-12. The winding is connected for three-phase with a series star connection. It will be observed that adjacent groups of coils in the same phase are connected for alternating voltages. That is, if you begin with phase A and trace this winding through diagram, first and second groups of coils form positive poles, while third and fourth form negative poles. The object of this diagram is to show that when these groups are connected in parallel for use on low voltages the groups in each parallel circuit will be properly distributed around the pole. One of the disadvantages of this form of winding is, however, that a very high voltage exists between some of the adjacent conductors, which means that a large amount of costly insulation must be used.

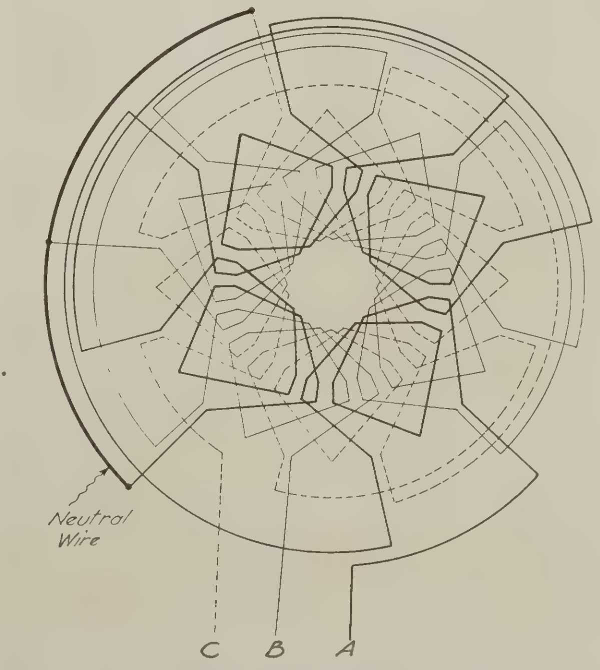


Fig. 8. Group Winding with Full Pitch, Having Four Poles, 48 Slots with a Throw of 1-12.

Simplified Windings.

As a rule, the shop electrician is not so much interested in how the coils are placed in the slots because spare coils are generally kept on hand, which are already wound and formed so the shop man's problem is to know how to connect these coils. So instead of showing a large variety of winding diagrams, we will describe a few end connection diagrams, which may be called simplified winding diagrams. By means of these, all methods of winding are represented by one or two general diagrams that will satisfy all conditions. Diagrams similar to Figs. 9 and 10 will represent any of the three-phase connections of coil loops which have been shown up to this time and may be applied to any similarly connected three-phase winding, irrespective of the number of poles, number of coils, number of groups and whether the windings have a full or fractional pitch. This form of winding diagram indicates that the phase windings are to be connected in either delta or star.

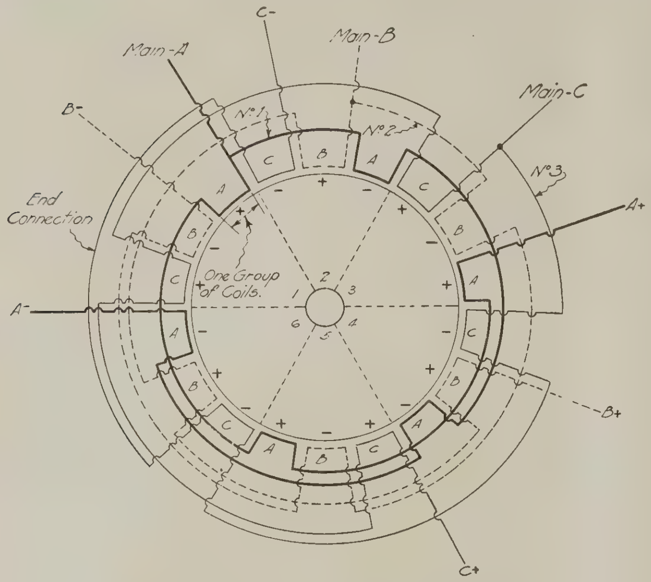


Fig. 9. Simplified Winding of Six Pole Three-Phase Machine for Operation on Two Voltages.

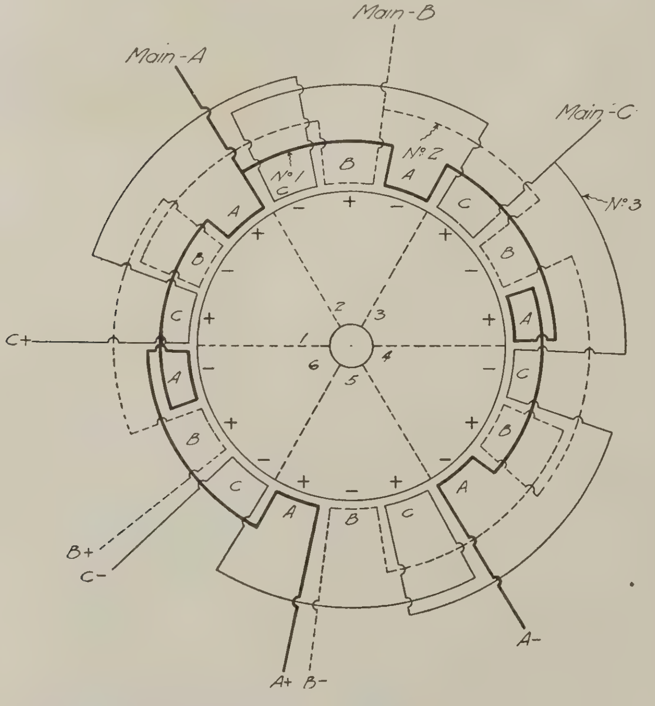


Fig. 10. Simplified Diagram of Six Pole Three-Phase Variable Voltage Winding.

Referring to Fig. 9, it will be noticed that in quadrant No. 1 the circular line A is marked "One Group." This means that the two ends of the line A represent the two end connections of a group of coils, which is formed by connecting the requisite number of coils in series or parallel. So the connections which are shown on this diagram show merely the connection of the groups of coils with each other. The diagram is divided into six segments, each of which signifies that the group terminals A, B and C, form one pole of the winding. There are always at least three times as many groups as there are poles for three-phase work and each group may be made up of a number of coils.

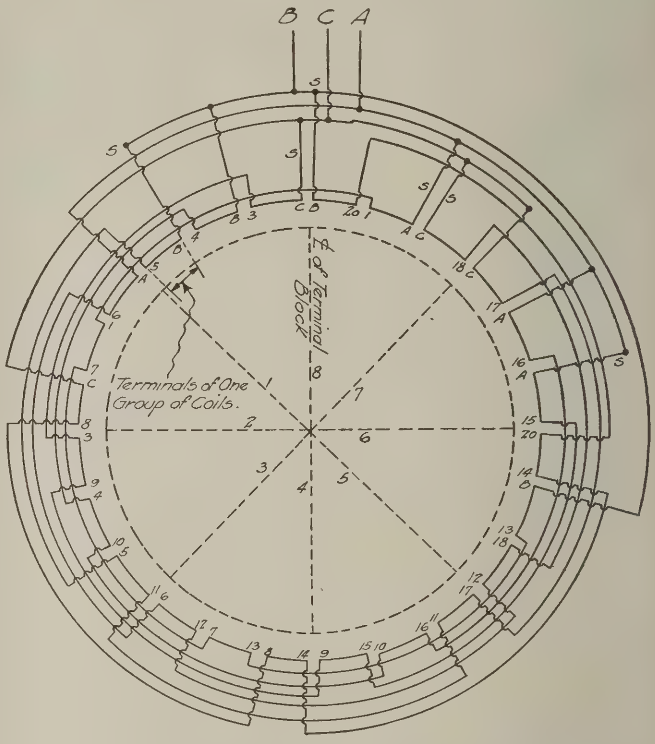


Fig. 11. Standard Westinghouse Parallel Delta, Three-Phase, 220-Volt Induction Motor.

Meaning of Coil Signs.

The signs, plus and minus, indicate the method of connecting that particular coil. That is to say, that if the current values for any instant are considered, the plus sign would mean that the current circulated in one direction around the coil, while the minus sign would indicate an opposite direction of flow. Plus can be assumed to mean that the current flows in a clockwise direction around a coil and minus, counter clockwise. The groups should be so connected that the instantaneous current flow will be as indicated by the signs.

Most modern motors and generators are so wound that they will operate with equal efficiency on two different voltages. For if a motor is wound for a certain voltage and gives satisfactory service it is obvious that if the winding is changed so as to have one-half the number of series conductors, but double the current carrying capacity it will give entire satisfaction on one-half the voltage.

To show the application of these diagrams, suppose Figs. 9 and 10 represent the connections to be used on a 220 or 440 volt, 6 pole, 3 phase induction motor. For 220 volt operation the groups would be connected in a parallel star and connections would be made as follows: A+, A—, B+, B—, C+, C—, are connected to a common wire or neutral, which forms the center of the star, and the leads marked Main A, Main B, and Main C would be connected to the three phase supply. For 440 volts the groups would be star connected but No. 1 would be disconnected from Main A and connected to A+, while No. 2 would be disconnected from Main B and connected to B+, while No. 3 from Main C and connected to C+, and connect A—, B—, and C— together to a common neutral which again forms the center of the star winding.

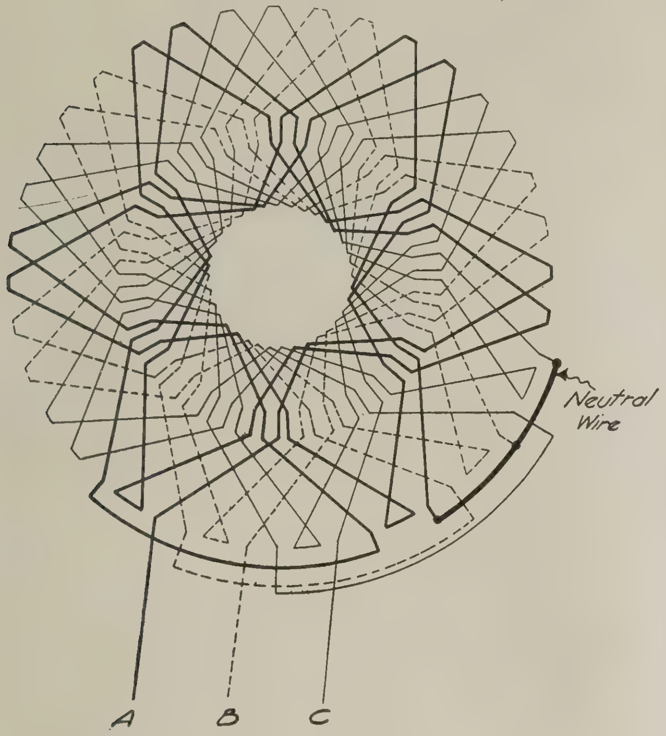


Fig. 12. Wave Wound Six Pole, Three-Phase, Machine.

If it is desired to connect the groups in a delta for 440 volt operation, proceed as with the star connection, except A— is connected to Main B, and B— is connected to Main C, and C— to Main A. For 220 volt delta connection, connect A+ and A— to Main B, and connect B+ and B— to Main C, and connect C+ and C— to Main A.

Polarity of Windings.

When connecting coils in an alternating current winding strict attention should always be given to the polarity of the different coil groups. The current at any instant in a star winding can be thought of as flowing into one phase and out of the other two. Trace these instantaneous currents through the different windings. Now, bearing the right hand screw rule in mind, which gives the relation of the direction of current to the polarity of the coil, see that each coil in the winding has the correct polarity. It will be remembered that at any instant the winding is divided up into north and south poles. If a coil which is in the region of a temporary north pole is found to set up a south pole it is obvious that it is connected in wrong and its terminal should be reversed. In two-phase work the only necessary precaution in determining the proper polarity is to remember that the adjacent groups of the same phase are reversed in polarity.

The diagram showing Fig. 11, shows a standard Westinghouse, parallel delta, connection for an 8 pole, 3 phase, 220 volt induction motor. In order to change this for 440 volt operation it will be necessary to connect the two parallel groups of each phase in series, as has been shown in Figs. 9 and 10. In this diagram it will be noted that the group ends show what slots that the coil lies in, thus in section one the central group of coils is placed in slot 4 and slot 22, one terminal connects to phase-B and the other connects to a group of coils in the third segment. The letter "S" indicates the starting point of the various windings.

Wave Windings.

In a wave winding the correspondingly placed conductors under the various poles are connected in series. The connections proceed from pole to pole in one direction one or more times around the armature and not forward or back upon itself as in lap or coil winding. The different circuits are then connected to form the three-phase windings and the three-phases are connected in delta or star as may be desired. The total number of these circuits must be a multiple of the number of phases and is ordinarily twice. This form of winding has a number of objections and is not used as extensively as the group form of coil winding. For one reason this form of winding does not lend itself as readily to machine methods of construction as the coil winding. The use of the wave winding is confined principally to the winding of rotors for variable speed motor and for winding large alternators.

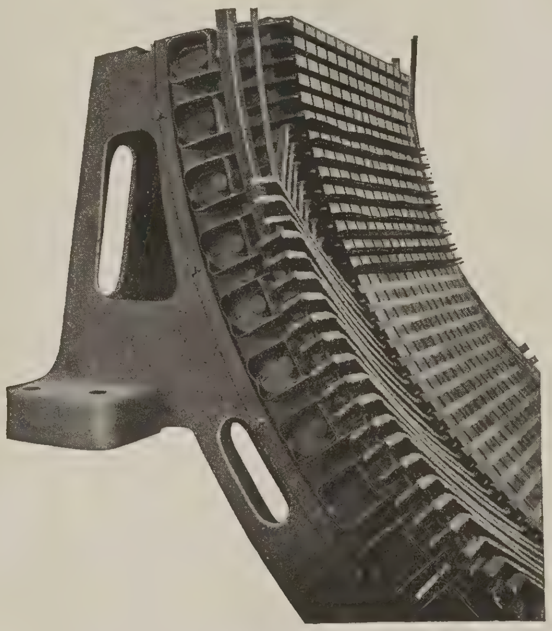


Fig. 13. Small Section of a Stator Winding of a Large Alternator, Showing the Method of Assembling the Coils.

When the rotors of induction motors are wave wound, collector rings must be supplied to the machine for each phase so that resistance can be inserted for starting. The number of slots in this type of winding is chosen so as to be devisable by the number of pairs of poles, or preferably, by the number of poles. If the pitch is plus one it would be a progressive winding. Since after traveling once around the circuit it returns to the starting slot plus one. A winding which has a pitch minus one is said to be a retrogressive winding since the circuit returns to the starting slot minus one. With these windings it is impossible to exactly balance the phases but where there is a great number of slots the effective unbalanced condition is so small that it may be neglected. An unbalanced three-phase winding is, however, less objectionable than a two-phase winding, for the latter requires an additional slip ring, which should be avoided when possible. It is for this reason that nearly all two-phase and three-phase motors have their rotors wound three-phase. The detrimental action of this unbalanced condition is not as great on the secondary winding of a rotor as it would be in the primary, so this objection need not be considered for practical purposes.

It is possible, by choosing a number of slots which is devisable by the product of the number of phases by the number of poles, to lay out a winding which is evenly balanced and which is suitable for a generator winding. In such a case, after the circuit has passed around the armature or stator it returns to the starting slot and it is then only necessary to supply a special connector to join it to the conductor which is located plus or minus one from the starting slot.

Fig. 12 shows a wave winding for a three-phase machine having 6 poles, 36 slots, 36 coils, 2 coils per slot, each coil having a throw from 1 to 7. The machine is connected for series star operation. This winding embodies the best features of both types of windings as far as electrical balance is concerned and a minimum number of end connections is obtained, which means a very compact and easily assembled form of winding. The number of special connectors is also comparatively small when compared with the total number of coils, this feature being more pronounced where the number of poles is greater, as in the case of a large slow-speed alternator.

If the path of any conductor is followed, beginning at any point such as "A," it will be noticed that it follows a circular path around the element and that it passes through the slots it is passing in the same direction regardless of the direction it is passing around the core. This keeps polarity of the different windings correct.

Fig. 13 shows a small section of a stator winding of a large alternator and shows the method of assembling the coils. In this case the coils are made up of flat bar copper and each coil is made up of two parts, the ends being fastened together by a special connector. Before the coils are assembled in the core the slots are lined with press board and horn fibre, which not only serves to protect the coils from mechanical injury, but also aid in insulating them electrically. The coils are held in place in the slots by wooden wedges in so firm a manner that vibration of the coil and consequent chafing of the insulation is imposible. All connections of the coils are firmly soldered and the leads carefully insulated.

The Principles of Alternating Currents

Williard Doud

Three phase current was defined in the preceding issue as a triple series of impulses or waves differing in phase position with each other by a fixed relation of 120 electrical degrees, transmitted over a three wire circuit.

It has been shown that single phase current may be produced by revolving a single coil about a fixed axis in proper relation to a magnetic field; also that two phase current is produced by revolving two coils, separated by a certain angular displacement (90 electrical degrees), about a fixed axis in a similar magnetic field. To produce alternating current of any number of phases it is only necessary to provide as many generating coils as there are phases to be produced arranging the coils with a proper fixed angular displacement and revolving them about an axis in a suitable magnetic field.

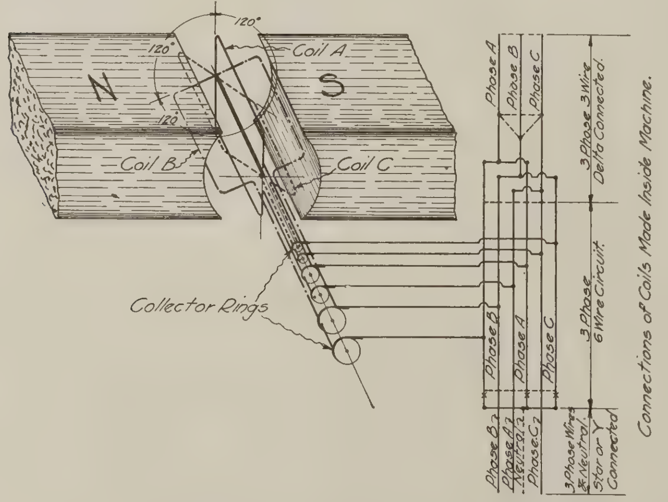


Fig. 13. Elementary Three Phase Generator.

Fig. 13 shows an elementary three phase generator constructed according to these requirements with three generating coils arranged to revolve about a fixed axis placed in proper relation to a magnetic field. It will be noticed that six collector rings, two for each phase or circuit, are shown for conducting the current from the generating coils to the three exterior circuits and that the construction of the generator, with the exception of generating coils and collector rings, is the same as that of the simple generator shown in Fig. 1.

Advantage of Polyphase Machinery.

At this point it might be desirable to give reasons why polyphase alternating current or current of more than one phase is more desirable for general use than single phase current. Also the advantages of three phase current, the use of which has become universal in the field covered by alternating current, excepting, of course, instances where single or two phase current meets some special requirement of an industry or service.

It has been stated that the polyphase motor and generator require less copper and so are lighter and cheaper to manufacture than single phase machines of like capacity and the polyphase motor is simpler, less liable to get out of order and has better starting and overload characteristics than the single phase motor. In addition to these advantages, three phase distribution of power is very economical in the use of copper. This is a very important item where a large amount of current is distributed over a wide area.

The following tabulation shows the relation in the size of the combined conductors (in circular mils) required for various systems of distribution where the power transmitted, distance and line loss are constant. The comparison expresses the ratio in per cent of the combined size of the conductors of the system under consideration to the combined size of an equivalent single phase system:

System of Distribution.	Per Cent Size of Conductors.
2 wire single phase	100
2 wire direct current	100
4 wire two phase	100
3 wire three phase	75

Thus each conductor in a three phase system is just one-half the size of either of the conductors of an equivalent single phase system. There are, however, three conductors in the former system and two in the latter, so the ratio of the amount of copper in the three phase system to that in an equivalent single phase system is 75 per cent.

Increasing the number of phases in alternating currents necessarily complicates the construction of the generator and also adds somewhat to the difficulty of making a clear and simple explanation of all the features which are peculiar to alternating currents. This being the case the reader should try and follow closely all the points brought out in the diagrams and text and not depend too much on the hydraulic analogy of a three phase generator which is used in this article.

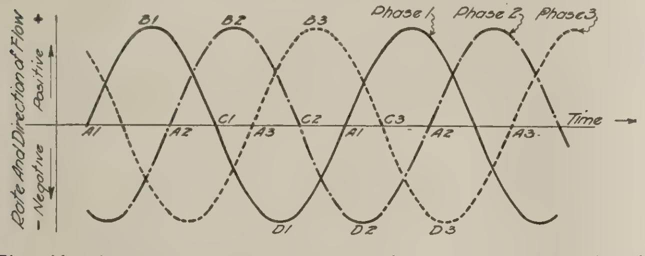


Fig. 14. Instantaneous Values of Voltage and Current in the Three Phases of a Three-phase Generator.

Consideration of Fig. 13 might lead to the impression that the coils are placed 1/6 of the amature circumference or 60 degrees apart, but as the separation or displacement applies only to the same sides of the generating coils it will be seen that one side of a coil is 120 degrees from the similiar side of the the other two coils.

While it would be possible to have a three phase generator with three separate coils and six wires leading to three outside circuits as shown in the diagram, this is almost never done, the windings or coils being connected together inside of the machine so that it is necessary to bring out only three or four wires for the three phases, the number depending on the method used for connecting the coils.

This proceeding of connecting the terminals of the generating coils together inside of the machine has the effect of reversing the effect of the electro motive forces in the vector diagram so that in spite of the fact that the generating coils are displaced by 120 degrees, it is found that the voltages combine at 60 degrees.

Fig. 14 shows the instantaneous values of the current and voltage of each phase obtained from the three phase generator outlined in Fig. 13.

As in Figs. 3 and 12, the horizontal line represents time, the distance above this line, rate of flow in a positive direction and below the line, rate of flow in a negative direction. It will be noted that similar values of rate and direction of flow of the different phases at any instant are 120 degrees apart and maintain this relation without change. Attention is also called to a very important characteristic of three phase currents, namely, that at any instant the flow of current in a 3 wire three phase system in any one direction for any phase is sufficient to balance the flow in the other two phases which is in the opposite direction.

Hydraulic Analogy of Three Phase Generator.

A representation of the rates and direction of flow occurring in a three phase generator by use of a hydraulic analogy is shown in Fig. 15.

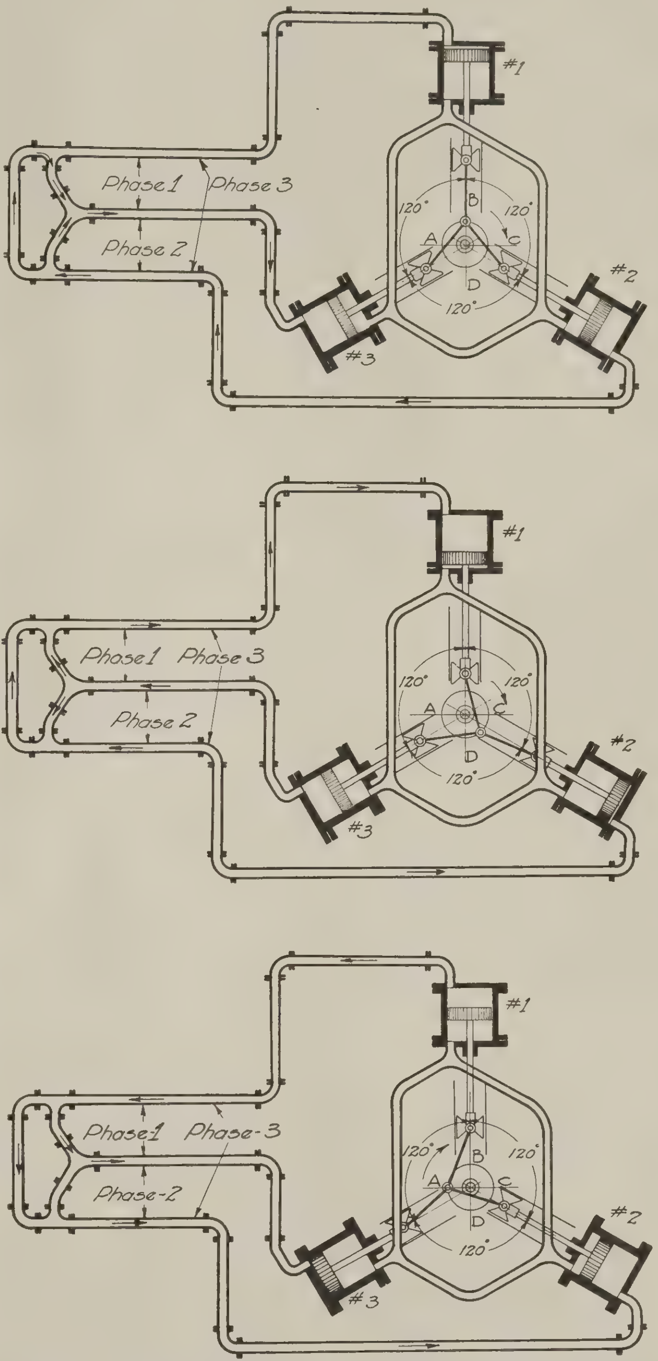


Fig. 15. Hydraulic Analogy of the Three-phase Generator, the Flow of the Water in the Pipes is Analogous to the Current Flow in a Generator with Different Positions of the Armature.

The mechanism shown consists of three cylinders located equi-distant from and around a shaft which operates the pistons in the cylinders by means of the ordinary crank, connecting rod and crosshead arrangement. The cylinders are separated from each other by an angular displacement of 120 degrees and are connected on the head and crank ends by closed systems of piping arranged to allow transmission of water from each cylinder to the others and vice versa.

A study of the action of this mechanism for the various crank positions A-B-C-D will show that considering the three pipes leading from the head ends of the cylinders or the three pipes leading from the crank ends, that the flow outward in any two of the pipes will always balance the flow inward in the other pipe. This characteristic makes it possible to combine three of the pipes into one pipe for connecting the crank ends of the cylinders. This proceeding is similar to the practice of connecting like terminals of coils in three phase generators together in a common junction.

The flow of water in the three pipes leading from the head ends of the cylinders is also represented by the curves shown in Fig. 14, which illustrates the values of current and voltage for a three phase system.

The hydraulic analogy of a three phase generator fails to show clearly one important characteristic of three phase currents, namely that while the amount and pressure of the water flowing in the pipes leading from the cylinders corresponds to the voltage and the current flowing in each of the wires of a three wire three phase system the current flowing between the wires, as well as the pressure, may not be the same, but 1.73 times the pressure or amount of water flowing in the two pipes leading from the same cylinder.

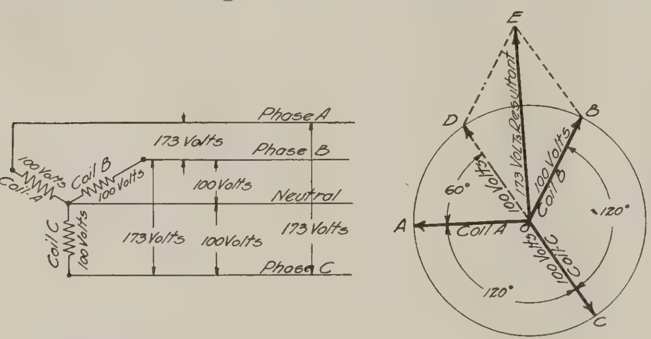


Fig. 16. Star Connected Armature. Voltage Diagram on the Right Shows the Method of Finding the Resultant Voltage Across Any Phase.

Vector Diagrams.

Fig. 16 shows a method of connecting together the coils of a three phase generator on the star or Y plan, together with a vector diagram showing the results obtained from using this method. It will be noticed that the coils are shown displaced 120 degrees apart and the arrangement is made as suggestive of the number of phases and method of connecting the coils as is possible. Three wires are led, one from each terminal and a fourth which may or may not be used, from the common junction of the coils.

A vector diagram is drawn by dividing a circle into three divisions of 120 degrees each (Fig. 16) representing the generating coils and their angular displacement.

Connecting like terminals of the coils together has the effect of reversing the voltage 180 degrees. This is equivalent to reversing the line OC, representing coil C, by a dotted portion until it meets the circumference of the circle and drawing DE and BE equal and parallel to OD and OB, a diagonal OE is obtained, which, if the diagrams has been accurately drawn, will equal 1.73 times line OA-OB or OC and represents the voltage across any two of the coils, which in this instance is 173 volts. The voltage between any phase wire and the neutral is, of course, the voltage of the generating coil connecting these points or 100 volts. So with a star wound armature the line voltage is 1.73 times the voltage of one phase winding.

Fig. 17 is a wiring and vector diagram of the mesh or delta plan of connecting generating coils of a three phase generator, so called on account of its fancied resemblance to the Greek letter Delta. The coils are connected in triangular or Delta form and phase wires are led out from each corner of the Delta.

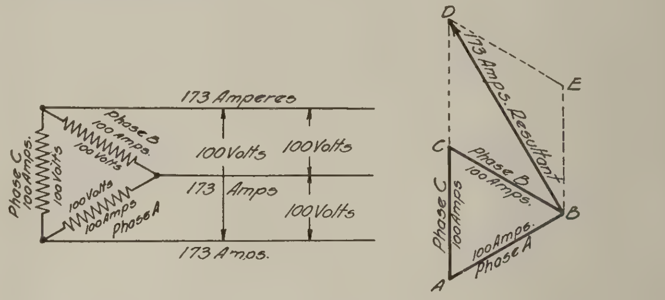


Fig. 17. Delta Connected Armature. The Phase Voltage is the Same as That of a Generating Coil. Vector Diagram Shows How to Find the Resultant Phase Current.

The voltage of the external circuit is equal to the voltage of one phase of the armature winding. This feature may be explained, by the fact that between any two points of a Delta connected system to which one coil may be connected there exists an equal and opposite electro motive force due to the action of the other two coils.

Owing to this characteristic such a system no current will flow around the Delta when the machine terminals are on open circuit for the resultant voltage around the Delta is always equal to zero. This can be proved by consulting Fig. 14 where it will be seen that the instantaneous voltage in one phase is equal to the sum of the voltages in the other two.

A vector diagram to determine the current flowing between two coils of a three phase Delta connected generator also is included in Fig. 17. With a current of 100 amperes flowing in each coil the current in each phase wire will equal 173 amperes because it is the combined current obtained from two coils differing in phase relation with each other by 60 degrees and out of phase with the resultant by 30 degrees.

The current diagram is drawn by letting the lines AB, BC, and CA represent value and phase position of the current in phases A, B and C, respectively. To find the current flowing terminal C of the Delta, draw BE equal and parallel to AC and then complete the parallelogram which gives BD as a resultant, or 173 amperes. This, then, represents the value and phase position of the current flowing from terminal C.

This diagonal will equal 1.73 times the length of either CB or AC and represents in this particular instance 1.73 amperes flowing between the points A and B which represent the terminals of the generator coils.

In this arrangement the voltage between any two wires is the same on account of the pressure between two wires is that of the coil to which they are connected and this principle of constant voltage is perhaps the most important feature of the delta connected generator.

The number 1.73 is very important in three phase work for it is the factor used to find the resultant voltage or current from the voltage or current in the two phases combined. This together with the number 1.41 which is the factor for combining voltages and currents in two phase work, should be constantly borne in mind.

The Railroad Electricians' Club

R. R. Electrician's Club of Chicago

At the April meeting of the club it was decided that, instead of trying to continue the club on its present basis without dues or a definite membership, as has been done in the past, it should be better organized. An election of officers was held and Mr. C. J. Causland, chief electrician Pennsylvania Railroad lines, west, was elected president and Mr. George B. Colgrove, vice president, and Mr. Edward Wray, *Railway Electrical Engineer,* secretary-treasurer, The following membership dues were decided upon: Senior active members (chief electricians and electrical foremen), $1.00; junior active members (railroad electricians, inspectors and batterymen), 50 cents; associate members (supply men, etc.), $1.00.

It was decided that there would be no meetings held during the summer months of June, July and August and that this reorganization with the new club membership will not become effective until fall. It is planned to have dinner meetings at 6:30 p. m. in some downtown hotel or restaurant, which would be followed immediately by a talk or other program. The club expects to purchase a reflecting stereopticon so that talks can be well illustrated. The program committee is planning on having two ladies nights during the year.

The May meeting which will be the last of the season will be held at 8:00 p. m., May 24th. At this meeting the subject of the "Ampere Hour Meter in Car Lighting Service" will be fully discussed. Mr. R. C. Lanphier of the Sangamo Electric Company will tell us about the construction and principles of operation of the meter and it is expected that Mr. W. L. Bliss of the United States Light and Heating Company, and Mr. T. L. Mount of the Consolidated Company, will describe the application of the ampere hour meter principle to their respective systems.

Pacific Coast Railway Electrical Club

This club was organized at San Francisco last summer and has met regularly each month. Meetings have been very well attended and the members are enthusiastic over the club work. They have taken up the various lessons of the A. B. C. Car Lighting course and the P. R. R. School of Electricity as published in the *Railway Electrical Engineer* and carefully studied and discussed these lessons at the meetings. At present there are sixty-one members and the usual attendance is about forty-five at every meeting. Mr. J. J. Hack, engineer train lighting, heating and ventilating, Pacific Company, was president during the past year, and at a recent election of officers the following were elected: G. C. Egelston, of the Pullman Company, president; C. R. Alexander, Sante Fe, vice-president; and T. C. Szchokke, of the Southern Pacific Company, secretary-treasurer. The club meets on the third Friday of every month.

Edison Storage Battery Questions.

Separators.

Q. 10. What do the Edison battery separators consist of and how are the lining sheets applied?

Ans. 10. Separation of the plates is accomplished by fitting their edges into spacing insulators of hard rubber placed at the sides of the cells. These insulators are of ladder construction, and are provided with properly spaced slots into which the edges of the plates fit. Between the plates are also placed long thin hard rubber pins. Seven of these are placed between each positive plate and its adjacent negative plate. There are no sheets of either rubber or wood between the plates as in the lead battery.

Containers.

Q. 11. How is the container or jar made, and why are the cells sealed by welding the cover to the jars?

Ans. 11. The container or battery jar is made of sheet steel which is heavily plated with nickel. All edges both at the top and bottom are welded together by means of an oxy-acetylene flame. The sides of the can are heavily corrugated, this makes the jar strong and proof against denting.

The cell is sealed by the manufacturer because it should not be necessary to remove the elements during the entire life of the battery and no railroad company is equipped to replace defective tubes or pockets.

Battery Trays.

Q. 12. How is the Edison battery tray constructed and how are the cells supported in this tray?

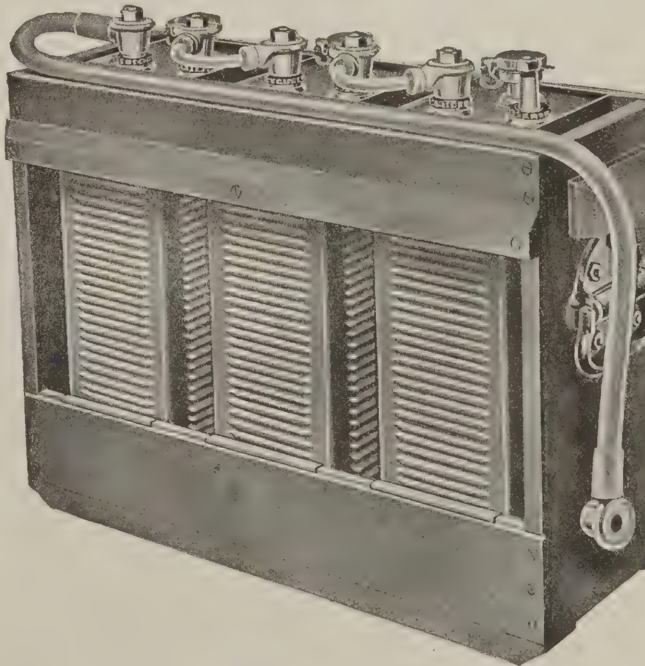


Fig. 8. Edison Cells Mounted in Tray.

Ans. 12. Battery trays are built up of wood with open sides, as shown in Fig. 8. The cells are supported at each of the side slats of the tray by means of steel bosses that are electrically spot welded to the sides of the cell container. These bosses fit into recessed hard rubber buttons that are supported in the tray slat. This construction leaves the entire bottom of the jar free from contact with anything which might cause grounds and electrolysis.

Terminal Posts.

Q. 13. What metals are the terminal posts made of and why are they built with a taper fit?

Ans. 13. The terminal posts are made of heavy steel and connect to the plates by means of a steel rod to which the plates are bolted with spacing washers between. The terminals posts, like all other parts of the battery, are heavily nickel plated and pass through a rubber bushing at the cell cover, made both gas and water tight. The tops of the posts are tapered so that when the connector, which has a similar taper, is bolted in place, a small pressure of the bolt will cause a great contact pressure on the taper between connector and terminal post.

A. B. C. Car Lighting Course

Edited by Edward Wray

Lesson No. 40

A. B. C. Car Lighting Course

It is very evident that where the voltage coils of axle car lighting equipments are set in the coach yard instead of in actual service on the road, not only will a great amount of the inspector's time be saved but the work will be more carefully done since a constant voltage can easily be maintained in the yard, and this is rarely possible on the road. Although this article refers to the Safety Type D and F regulators, and the U. S. L. panels, it can easily be applied to other systems.

Method of Setting Safety Combination Current and Voltage Regulators—Car in Yard.

In order to properly adjust a regulator of this type it is first necessary to eliminate mechanical resistance as near as possible; all pins and pivots should be thoroughly cleaned with a very fine emory paper and flake graphite applied to the bearing surfaces. Oil should not be used for lubrication as dust quickly collects in the bearings where oil is used and in a short time the regulator will be in a worse condition as far as mechanical resistance is concerned than before it was oiled.

Then proceed as follows:

First: Inasmuch as a minimum voltage of 50 volts (30-volt system) is required, it would be necessary under ordinary conditions to train line to another car and connections made as follows: See Fig. 202.

First open the train line switch, then with the switch open, connect the positive blade of the switch to the negative clip by means of a fuse or short jumper. Then connect the lead to the positive clip of the train line switch, connecting the other end of this lead to one terminal of a small adjustable carbon pile "R." Disconnect the positive terminal of the voltage coil from the panel and connect a lead from the positive terminal of the voltage coil to the other terminal of the small adjustable carbon pile "R."

Now, inasmuch as the negative terminal of the voltage coil is permanently connected to the negative side in car "C," the circuit is now complete, the batteries in car "C" and "C-1" are in series and the combined voltage of these batteries is impressed on the voltage coil (less the drop across the small adjustable carbon pile "R"). So the voltage impressed on the coil "A" can be varied at will by varying the pressure on carbon pile "R."

A volt meter "V" should now be connected across voltage coil and resistance unit at points "E" and "E-1."

The first operation in adjusting the regulator is as follows: The voltage impressed on the voltage coil should be reduced to the minimum by decreasing the pressure on the carbon pile "R," which will allow the voltage end of the regulator arm to reach its limit of downward travel. The pressure on the carbon pile should now be gradually increased, thus increasing the voltage impressed on the voltage coil until the arm starts in an upward movement.

The first movement will start at a voltage considerably lower than the voltage necessary to raise the arm to the limit of its travel due to the cushion effect of the carbon pile. The inspector should not be misled by this however, as this influence will only be noticeable at the beginning of the upward travel. The voltage impressed on the voltage coil should be just sufficient, and no more, to carry the arm to the limit of its upward travel. The tension spring should then be so adjusted that this voltage will be exactly 38 volts for a Safety type "D" regulator and 37 volts for Safety type "F" regulator.

The pressure on small carbon pile "R" should then be decreased until the arm travels downward to the point where it comes under the influence of the cushion effect of the carbon pile. If the mechanical resistance has been properly taken care of this minimum voltage will not be more than 4 volts less than the maximum voltage of 38 volts, that is 34 volts.

If, after the regulator is adjusted, it is found that the cutting-in speed is higher than normal this can be eliminated by removing a number of the thin discs and replacing them with 3 or 4 thick discs such as are used in connection with the lamp regulator.

After a regulator has been set as per above instructions, no further adjustments should be necessary unless it is desired to change the voltage at which the regulator is to operate.

If at any time afterwards the regulator is found to be out of adjustment it can almost invariably be traced to mechanical resistance due to corroded conditions of bearing surfaces or to high resistance of carbon pile in the regulator caused by dust or other foreign matter being lodged between the discs. If upon examination the discs are found to be burnt or pitted they should be replaced with new ones.

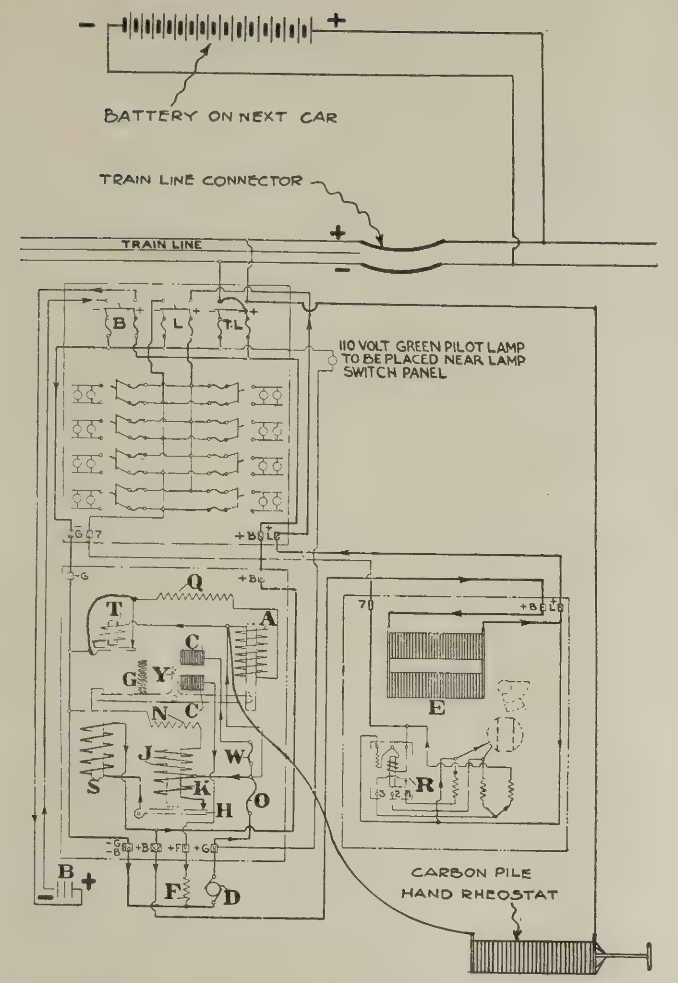

BATTERY ON NEXT CAR
TRAIN LINE CONNECTOR
TRAIN LINE
+
−
B
L
TL
110 VOLT GREEN PILOT LAMP TO BE PLACED NEAR LAMP SWITCH PANEL
Q
T
A
C
G
Y
N
C
J
W
S
K
H
O
E
R
B
F
D
CARBON PILE HAND RHEOSTAT

Fig. 202. Wiring Diagram of Safety Regulator for Yard Adjustment.

Method of Adjusting the Automatic Switch—Car in Yard.

In order to properly adjust the automatic switch with the car in the yard, the same train line connections should be made as outlined under regulator instructions, with the exceptions of course that one end of the carbon pile should be connected to the detached positive terminal of the automatic switch-lifting coil instead of the voltage coil. This will of course connect the batteries in cars "C" and "C-1" in series and impress a voltage of 60 volts on the lifting coil of the automatic switch, less the drop across the small adjustable carbon pile. The pressure on the carbon pile should then be reduced to the minimum and a voltmeter "V" connected across the resistance and lifting coil at points "E" and "E-1." The pressure on the carbon pile should be gradually increased until the voltmeter shows a reading of 33 volts, at which voltage the automatic switch should close, and if not the air gap should be increased or decreased until the automatic switch closes at exactly 33 volts.

We are indebted to Mr. H. R. Pennington, traveling electrician of the Rock Island lines, for his cooperation in preparing this lesson.

Methods of Adjusting U. S. L. Stop Charge Relays in the Yard.

Any voltage coils which do not require a very heavy current, such as stop-charge relay coils of the U. S. L. system, can very conveniently be set in the coach yard by employing a bank of small dry cells as shown in the accompanying illustration, Fig. 203. These dry cells are of the ordinary hand flash lamp type with three cells per tube. The screws at the end of the box make contact between the cell terminals and strap connections. These strap connections are arranged so as to connect all of the twelve cells in series. Taps are then carried out to the contact buttons, so that there is a voltage step of about three volts between consecutive positions of the contact arm. The three screws immediately under the handle of the case make contact direct with the zinc casing of each of the individual cells in that tube, therefore, the final adjustment to the voltage desired can be obtained by making connection direct to one of these screws after the approximate voltage has been attained by adjustment of the contact arm.

The dry cell box should be connected in series with the stop-charge relay at one of the relay winding posts. This is done by disconnecting one of the terminal wires of the relay and connecting in the battery box at this point. The volt meter should be connected across the terminals of the stop charge. In the battery current to this point remove the dynamo fuse and block the automatic switch closed with a piece of wood. When the voltage across the coils is brought up to the proper value by the relay armature adjusting screw, the air cap of the relay armature can be adjusted so that it just closes at this voltage. One volt higher or one volt lower can be obtained by shifting the connections on the adjusting box or if this does not give the desired result, closer voltage adjustment can be made by turning on one or more lamp circuits. It must not be forgotten that the relay coils are generally cold when set in the yard, and allowance must be made for this temperature effect. Two volts is a fair voltage difference between hot and cold coils.

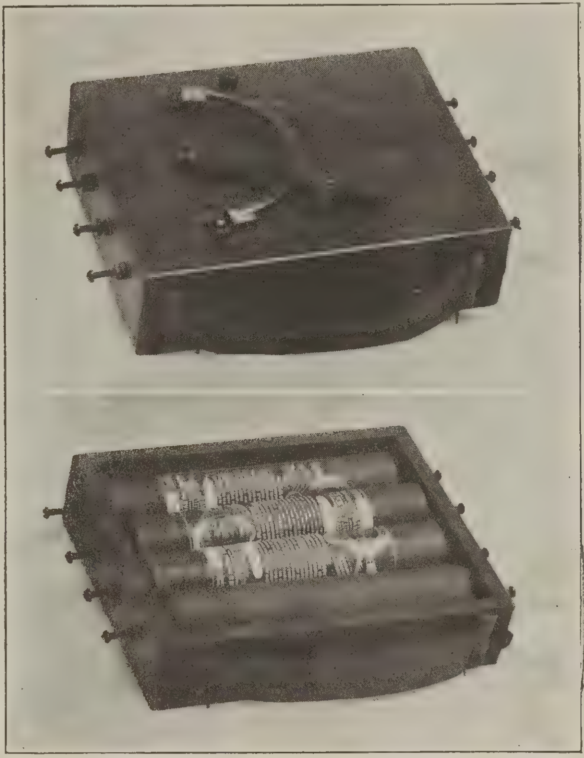


Fig. 203. Dry Cell Battery Box (Above) Showing Adjustable Contact Arm for Varying the Voltage. Below, the Box Is Shown With Cover Removed Showing How Cells Are Arranged.

This voltage adjusting box was designed and constructed Mr. H. G. Myers, electrical foreman, Santa Fe, Chicago.

Practical Stunts

We Pay a Dollar Apiece for Practical Stunts—Send in Your Ideas

Yearly Greasing For Axle Generator Ball Bearings.

Shortly over a year ago when it was first suggested that car lighting generators equipped with ball bearings might be operated for a period of six months without any attention whatever being paid to the ball bearings, many people were more or less skeptical as to the outcome. The accompanying illustration, however, shows how well the bearing lubricant holds up during six months continuous service during the winter months, at least.

This machine mounted on Santa Fe car No. 2970, was received from the shop where the bearings had been properly greased about the middle of October, 1914. The car operated between Chicago and Kansas City daily and was in service all through the winter without interruption and the bearing was given no attention whatever. Upon being opened at the Santa Fe yards, Chicago, April 22, 1915, the bearing was found to be in good condition and there was plenty of reserve grease remaining in the bearing cup, as will be noticed from the accompanying illustration.

Generator Bearing Opened for the First Time in Six Months.

This particular equipment could probably run through the summer without difficulty, as nearly half the original supply of reserve grease still remained in the bearing and this grease was not even discolored. During the summer months this grease would have gradually softened and fed into the bearing, keeping it well lubricated. As a general proposition, however, it would probably be a little risky to plan on greasing the ball bearings only once a year, but with an additional charge from the grease gun, of not more than two-thirds the amount originally applied, the machine could undoubtedly run a year without cleaning and thoroughly greasing.

Undercutting Mica with Armature in Place.

One of the commonest sources of trouble in the operation of railway type motors is bad sparking at the brushes when the mica of the commutator gets high. This type of motor is employed in various classes of service such as in railway shops for traveling cranes and derrick operation, and they also find extensive use for the operation of draw and bascule bridges.

The task of undercutting mica is generally done during the overhauling of motor, when the motor casting is taken apart and the armature taken out. It is always attempted to have this done when that particular machinery is not required for service, or if conditions are too bad the machine is sometimes stopped and repaired when conditions will permit so doing.

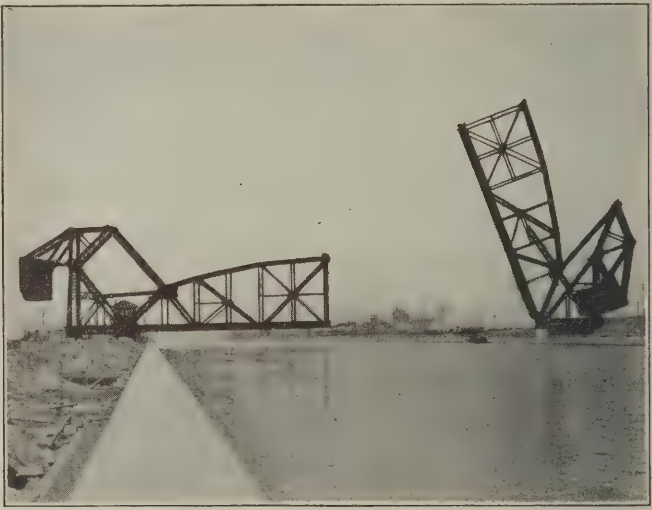


Fig. 1. Large Double Leaf Bascule Bridge Showing Large Area Exposed to Wind. This Greatly Increases Motor Load.

The writer had occasion to repair motors of this class which were troubled with high mica and which could not be even temporarily thrown out of operation. These were in the operation of a double leaf bascule bridge which is shown in Fig. 1. This bridge normally stands open during the navigation season owing to the large number of vessels which pass and it is only closed for the passage of trains. Here the situation was not quite so simple owing to the fact that the motors and the operating machinery are up in the air and in a vertical position, so to take the motor casting apart was out of the question. Last summer when the bridge was put in operation the motors were in good shape, but during the operations sometime last fall at the time when the stormy season started, the wind blew very hard which threw an additional load of motors, this resulted in high mica developing on all four motors.

This occurred just at a time when all the motors should have been in good condition for the safe control of the leaf in high windings.

It seems that the designers of many of the later

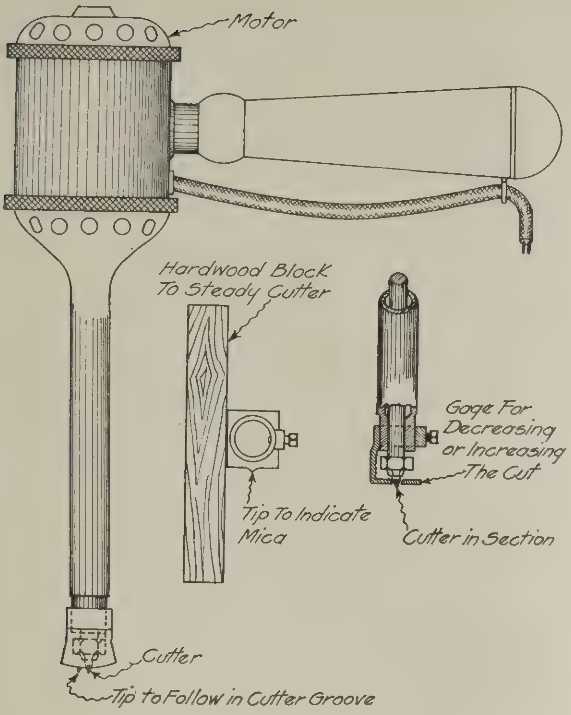

Motor
Hardwood Block To Steady Cutter
Gage For Decreasing or Increasing The Cut
Tip To Indicate Mica
Cutter in Section
Cutter
Tip to Follow in Cutter Groove

Fig. 2. Portable Tool for Undercutting Mica.

type motors do not pay particular attention to the fact that the mica must ofttimes be undercut without taking the motor apart. The opening on the commutator end is just large enough to change the brushes, but is too small to use any kind of a tool or scraper. Fig. 2 shows how this difficulty was finally solved by constructing a small motor-driven centrifugal cutter with an adjustable gage for different depth cuts.

This was constructed in the locomotive roundhouse shops where a lathe was available and the material gratis, except the wire to wind the field coils and armature. A small piece of hardwood block is a part of the equipment used in starting the cut. The cut is started and a steel guide following the motor guides the cut in the right direction automatically. The mica was undercut between train times and the method proved very satisfactory. However, this method is not to be recommended for the average shop man for it takes some considerable skill to construct such a motor and cutter. It would be a good thing for some manufacturer to make some such device on a commercial scale.

J. G. Koppel,
Elec. Supt. Bridges.

Prize Question Box

What is the Life of a Storage Battery?

In traveling about the country I hear a good many arguments, and, while most of them are usually settled in some manner, there is one question which no one has ever offered an answer to that seemed to cover it definitely.

It is impossible to mention batteries without referring to their life and up to the present I have never met anyone who can bring forward any method of computing it that would be considered practical.

Like everything else, I believe some standard should be agreed upon in connection with the life of a battery whereby anyone should be able to determine when a battery is fit to continue in service.

By the above statement I do not mean that a person should be called upon to guarantee the life of any battery, but I do claim that when the efficiency or capacity has dropped to a certain point, it would then be considered fit for scrapping.

A good many men consider a battery useless only when the parts have refused to hold together any longer. This is unfair, as I have already seen elements which appeared as good as new, but which were unable to deliver over 1-5 of their rated capacity.

We consider an incandescent lamp worn out when it has dropped to 80% of its initial candlepower. How about 60% A. H. efficiency at the 8-hour rate?

A Car Lighting Batteryman.

To the Editor: Referring to this question of life of a train lighting battery, some experience of roads operating in the United Kingdom may be of interest to your readers.

It should be noted, however, that in England practically all train lighting cells are made up in single units placed in lead lined teak boxes, with the exception of a few thousand elements mounted in glass and composition jars. The capacity of the batteries varies from 90 to 300 ampere hours, 12 cells are employed, giving a normal voltage of 24 volts. The lamp current of ordinary coaches varies from 8 to 12 amperes (192 to 288 watts), and for dining cars and Pullmans, varies from 20 to 30 amperes (480 to 720 watts).

It is impossible to place a definite percentage capacity on the life of a battery, as the various parts do not wear out simultaneously. These items may be considered under the following heads:

Positive Plates. One English railroad company with 50,000 cells in use finds that the average life is 7 years for positives; another company with 5,000 cells is use averages 6 years; and another road some positive sections or groups were in constant use for 12 years. This, however, is very exceptional. It is purely a question of mechanical strength, and the electrical capacity that determines when a plate should be discarded. This can obviously be decided by any practical man on the job, and no definite figure for depreciation can be given which will cover all cases.

Plates are the most important part of the cell, but it must be said that the results in battery life will vary greatly, depending on the system in use, service, etc. For instance, on one railroad on the continent which had several hundred vehicles, each fitted with one or two batteries on the straight storage system, the cell renewals per annum varied from 20 to 25%. When an axle generator car lighting system was installed on each car the repairs on batteries were brought down considerably.

Negative plates do not wear out mechanically but the pasted grid or lattice types lose considerable in capacity and electrical efficiency; the "sponge" or box types, however, seem to retain their capacity for a very much longer period. This is not always given sufficient attention, and frequently the old grid negative plates which have lost half their capacity are still kept in service. It is generally found here that one negative group will outlast two positive groups, so a life of from 12 to 14 years at least may be expected from negatives.

Battery capacity is rarely taken in train lighting service here, as time does not permit. Incidentally the metal filament lamps have greatly reduced the work imposed on the battery, and we are now getting a much longer life from both positive and negative plates.

Separators. Ebonite separators are broken only with handling when the battery is cleaned. Their life may easily be 20 years, but can just as easily be snuffed out in the first year or two in the hands of a careless man.

Sheet wood separators have a variable life, depending largely upon the number of times they are handled. They have been found in certain cases to stand up well, even after six years' service, having been removed six times during annual cleaning periods.

Side Sheets. Their life is governed to a great extent by their quality. The thick and soft, but more expensive ones will undoubtedly last some years longer, and be cheaper in the end than the less expensive, thin ones, which have a large percentage of sulphur and a small amount of rubber in them.

Boxes or Trays. Teak boxes are found to last about 12 years, although they may have to be repaired during this period. White wood, oak, etc., do not last so long. The battery jar covers usually have a much shorter life than the jar itself, particularly where these are fastened down with bolts.

Rubber Gaskets and Washers. Their life is also greatly dependent upon the quality of the material. It has been found most economical to put in the best rubber obtainable, which will then last about as long as the battery jar.

Connectors as made nowadays never seem to wear out, bolts corrode away here and there after 3 or 4 years, but generally they will last forever if they are not lost.

Wooden bottom blocks or tressels are perhaps the most frequently changed battery accessories, their life varying from 1 to 2 years. Those, however, having four bars for supporting positive and negative groups separately will last more than twice as long as the two-bar blocks. This same article made of porcelain has been tried, and should last indefinitely, but has not found general favor in England, owing to various reasons.

Lead linings were at one time a great source of trouble. Their life depends not only on the quality and thickness of the lead, but also on the insulation of the battery, for a ground on the battery will cause the lead to pit, provided the grounded current is flowing away from that lining to ground.

T. C. Elliott,
Train Lighting Engineer of the D. P. Battery Co., Ltd.,
Bakewell, England.

General News Section

Robert W. Pachaly

The many friends of Bert Pachaly will be pleased to learn of his recent advancement in the electrical department of the Rock Island. He has recently been appointed chief engineer and electrician in charge of the Chicago terminal.

Robert W. Pachaly.

Mr. Pachaly was born in Chicago in '81, and at the age of seventeen entered the Navy. This was at the beginning of the Spanish-American war and for four years he served in the Navy and saw much active service in connection with the Philippine insurrection and Morro troubles. In 1902 he sailed on the Great Lakes as engineer and pilot, and in 1904 he got his first experience in car lighting work, being then in the employ of the Consolidated Railway Electric Light and Equipment Company. In 1908 he entered the employ of the Great Western Railway as Car Lighting Inspector and in 1909 went with the Rock Island lines as traveling electrical inspector. In 1910 he was appointed electrical foreman in charge of car lighting on the Rock Island and this position he has held for the past five years.

Although he will still retain active charge of the Car Lighting Department, he will now also have charge of all terminal power light and heating, having the title of chief engineer and electrician. The Chicago terminal plant is equipped with a 2,000 horse power boiler plant and 2 500 kilowatt Curtiss turbines.

Mr. C. E. Walker Not Killed in European War as Rumored.

The many friends of Mr. C. E. Walker, representative of the J. Stone & Company, Ltd., London, will be pleased to learn that the rumor which has been so widely spread among car lighting men in this country that he had been killed in action at the front in northern France, is false. Mr. Walker is a second lieutenant in the Sixth Lanciers and is now with his regiment in Ireland enjoying perfect health.

We are also advised that he is looking forward to returning to the United States as soon as the war is over.

C. W. Bender Appointed General Manager Nela Specialties Division.

Mr. C. W. Bender has recently been appointed general manager of the Nela Specialties Division, recently organized to handle specialties manufactured by the National Lamp Works of the General Electric Co. Regular incandescent lamps will not be handled except in connection with such specialties which will include portable lamps. Trutint glassware, color matching units, special lamps, photolite lamps, and various other specialties.

C. W. Bender.

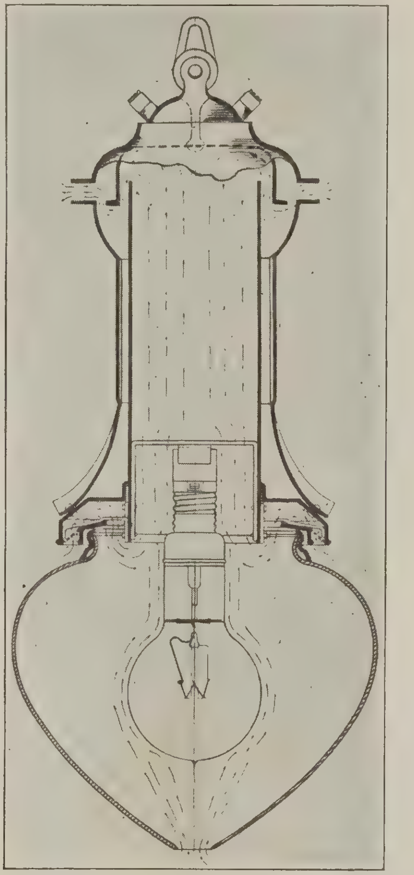
Mr. Bender has a wide acquaintance among the electrical men of the railroads, in fact, for 20 years was connected with the electrical department of the Pennsylvania R. R., and since then has been most actively cooperating with railroad men in improving lighting conditions and supplying lamps specifically designed to meet the conditions of railroad service. He for years has been a very active worker in all association matters, and in 1913 was elected president of the Ry. Elec. Supply Mfgrs. Association. His many friends among the railroad and railroad supply men will be very pleased to learn of his further advancement with the National Lamp Works.

Mr. Bender will continue as manager of the commercial department in addition to the new work given him, so that his activities in railroad work will in no way be lessened, but rather increased by his new appointment.

Mr. Edwin G. Hatch has resigned as Treasurer and Manager of the Clark Elec. & Mfg. Co., New York, to open an office of his own, where he will give particular attention to the specification, testing and purchasing of electrical material. Mr. L. I. Clark will succeed Mr. Hatch as the Company's Manager, New York.

Converting Arc Lamps Into Nitrogen Lamp Containers.

The introduction of the recently developed Type "C" (gas filled) lamp and its increasing popularity for street and commercial lighting has made necessary a new design of container for its successful and efficient operation. There were two ways of meeting these requirements: redesigning and converting the existing arc lamps into suitable containers, or the purchase of entirely new equipment. Of the many advantages offered by the first mentioned method, the most important was that of economy for after many tests and considerable experimenting, it was found possible to convert the arc lamps to a Type "C" lamp container at considerably less than that which would be charged for new equipment. From an operating standpoint there were two factors to contend with, first the absolute elimination of rain water in contact with the lamp bulb and second so housing or enclosing the lamp that the leading-in wires in the lamp would be operated at the lowest possible temperature.

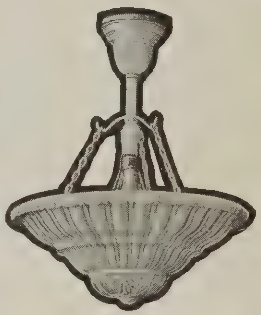


Arc Lamp Converted for Use with Nitrogen Filled Tungsten Lamp.

Protection from rain water was accomplished by the introduction of baffle plates within the housing and so designed as to absolutely eliminate the entrance of water and still provide sufficient clearances to permit air stream flow with the least possible resistance. As is well known, this type of lamp when burning tip down, the lamp base and all that section of the lamp within the cylindrical formation are subjected to comparatively high temperature and it was found essential to so design a unit as to operate this particular section at the lowest possible temperature.

ELECTRICAL

For All Classes of



The ALEXA-LITE is the last word in efficient office lighting. Ask for details.

A Customer Says:

"The 400-watt lamps with large base came in today and we are now enjoying a perfect office light; no dark corners, no shadows, no eye strain. Like so many other good things common today, but unknown to a previous age, we don't see how we got along without it. Will certainly make use of more ALEXA-LITES when opportunity offers."

"DELTABESTON" Magnet Wire is insulated with pure asbestos

A simple test to prove that "Deltabeston" Magnet Wire is entirely indestructible under commercial conditions is to couple a piece of "Deltabeston" with ordinary magnet wire and subject to the same currents. You may completely destroy the cotton covered wire without affecting "Deltabeston."

Have your Old Motors, when burned out, rewound with "Deltabeston" Magnet Wire, and specify it when ordering new motors.

The largest electrical companies have adopted "Deltabeston" Wire for winding their motors. Just specify "Deltabeston" Magnet Wire and don't confuse it with any other asbestos covering.

INVESTIGATE TODAY — LET US SEND YOU A FREE SAMPLE AND OUR DESCRIPTIVE FOLDER.

In addition to the above, we carry a complete stock in Chicago, for
dulets, linemen's tools, pole line material, glassware, reflectors, incan-
Special car material, such as car switches, distributing boxes, switch-
If it's electrical, we are in position to furnish it.

INQUIRIES AND ORDERS

Central Electric Company

"The House of Service"

320-326 So. Fifth Avenue Chicago

THE HOUSE OF SERVICE

FANS ARE STANDARD

STANDARDS

Railroad Work

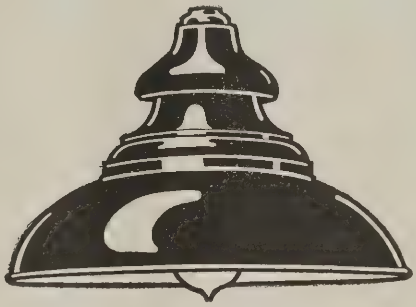
OKONITE

TRADE MARK.

The Highest Grade of Insulation Obtainable

This is just another way of saying Okonite—tough, elastic, of high electrical resistance, containing never less than 30% of the best quality dry, fine up-river Para rubber, always placed concentrically around the conductor. Result: Absolute Dependability.

Okonite is always made in one grade—The Best—and has for years been the standard for railway service.



The "Maxolite"

The Maxolite is one piece, stamped steel, porcelain enameled reflector, specially designed for use with the Type C lamp, therefore, ventilation is perfect, and with the Type R fitting can be wired in a jiffy.

An ideal lighting unit for

Shops	Trainsheds
Yards	Roundhouses
Platforms	Warehouses

Ask for Bulletin No. 43

immediate shipment, of standard makes of wiring devices, conduits, con-
descent lamps, etc., for shop, roundhouse, street and car work.
boards, fuse holders, wires and cables, are also carried in stock.

ARE SOLICITED

Central Electric Company

"The House of Service"

320-326 So. Fifth Avenue **Chicago**

FARADAY

BELLS AND BUZZERS

ELECTRIC HEATING DEVICES

PLUGS AND RECEPTACLES

With this object in view, many tests were conducted, finally resulting in a unit shown in cross-section in the accompanying figure. It will be noted that the entire design takes the form of a chimney with cold air entering beneath the lamp at the bottom of the globe which rises rapidly and becomes heated after enveloping the lamp bulb, passes upward with considerable volocity and in so doing induces a volume of cold air to enter above the top of the globe as illustrated. This particular cold air stream entering above the globe top and being directed against those lamp parts liable to high temperature caused them to actually operate at a temparature lower than would obtain if the lamp burned in free atmosphere.

The material needed to convert an arc lamp into a nitrogen lamp contained as herein described is handled by the Metropolitan Engineering Co., Forty-second Street Building, New York.

Mr. L. I. Clark has recently been appointed manager of the Clark Electric & Manufacturing Co., manufacturers of transmission line and power house materials. Mr. Clark is also assistant to Mr. W. G. Clark, consulting engineer, New York.

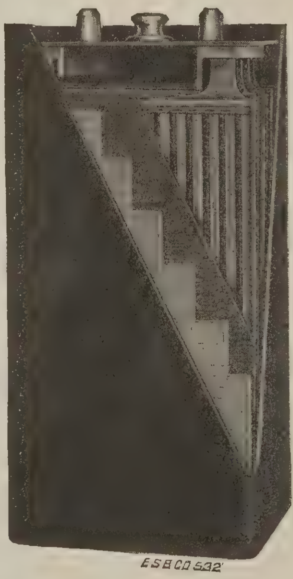
The Electric Fuseguard Co. has recently published a catalog describing their enclosed fuses and other electrical protective material. This is complete with prices.

The ninth annual convention of the Illuminating Engineering Society will be held at the New Willard Hotel, Washington, D. C., September 20th to 23rd inclusive. Mr. E. S. Marlow, of the Potomac Electric Power Company, Washington, D. C., is chairman of the convention committee. The schedule of sessions, papers, etc., will be announced later.

Committees

of the Association of Railway Electrical Engineers

President
H. C. Meloy, Lake Shore & Michigan Southern Ry.
Senior Vice President
E. W. Jansen, Illinois Central R. R.
Junior Vice President
C. J. Causland, Penn. R. R.
Secretary-Treasurer
J. A. Andreucetti, Chicago & North Western Ry.
Executive Committee
W. A. Del Mar, New York Central Lines.
J. E. Gardner, Chicago, Burlington & Quincy R. R.
J. J. Hack, Southern Pacific Ry.
J. L. Minick, Penn. R. R.
L. S. Billau, Baltimore & Ohio R. R.
L. C. Hensel, Frisco Lines.
COMMITTEE ON METAL CONDUIT SPECIFICATIONS
J. L. Minick, Chairman, Foreman, Penn. R. R.
COMMITTEE ON STANDARDIZATION OF CRANE, TURN TABLE AND TRANSFER TABLE MOTORS
H. C. Meloy, Chairman, Chief Elec., L. S. & M. S. Ry.
COMMITTEE ON WIRELESS TELEPHONE AND TELEGRAPH AS APPLIED TO MOVING TRAINS
Dr. Frederick Millener, Chairman, Custodian of Term., N. P. Ry.
COMMITTEE ON POWER PLANT OPERATION
J. H. Davis, Chairman, Elec. Engr., B. & O. R. R.
COMMITTEE ON COMPRESSED AIR GENERATORS
L. C. Hensel, Chairman, Chief. Elec., 'Frisco Lines.
COMMITTEE ON STANDARD RULES FOR CAR WIRING
Geo. B. Colgrove, Chairman, Chief Elec., Ill. Cent. R. R.
COMMITTEE ON STANDARDS FOR TRAIN LIGHTING EQUIPMENT
D. J. Cartwright, Chairman, Elec. Engr., Lehigh Valley.
COMMITTEE ON SHOP PRACTICE
D. C. Wilson, Chairman, Elec. Engr., Union Pac. Ry.
COMMITTEE ON ELECTRIC HEAD LIGHTS
E. W. Jansen, Chairman, Elec. Engr., Ill. Cent. R. R.
COMMITTEE ON DATA AND INFORMATION
Edw. Wray, Chairman, RAILWAY ELECTRICAL ENGINEER.
COMMITTEE ON SPECIFICATIONS FOR WIRE CROSSING FOR POTENTIALS ABOVE 100 VOLTS
J. R. Sloan, Chairman, Engr. Elec. Car Stg., Penn. R. R.
COMMITTEE ON INDUSTRIAL TRUCKS
T. V. Buckwalter, Mech. Dept., Penn. R. R.
COMMITTEE ON RECIPROCAL RELATIONS
L. S. Billau, Elec. Dept., B. & O. R. R.
COMMITTEE ON LOOSE LEAF BINDERS
J. R. Sloan, Engr. Elec. Car Stg., Penn. R. R.
COMMITTEE ON ILLUMINATION
L. S. Billau, Elec. Dept., B. & O. R. R.
COMMITTEE ON WIRE SPECIFICATIONS
Wm. A. Del Mar, Chairman, Asst. Engr., N. Y. Central Lines.



The "Ironclad=Exide" Battery
For Locomotive Headlights

Many railroads are considering the use of electric headlights for locomotives.

The Southern Pacific Railway Company have 946 locomotives equipped with electric headlights and "Ironclad=Exide" Batteries.

The characteristics of this battery make it particularly suited to the requirements of this class of work. It is rugged, has long life and can be operated for much longer periods without cleaning than any other type.

Our engineers have carefully studied this subject and will be glad to co-operate with you, furnishing you with any help or information you desire. Write our office nearest you.

THE ELECTRIC STORAGE BATTERY CO.
MANUFACTURER OF
The "Chloride Accumulator", The "Tudor Accumulator"
The "Exide", "Hycap=Exide", "Thin=Exide" and "Ironclad=Exide" Batteries

New York Boston Chicago Rochester St. Louis Cleveland Atlanta Detroit
PHILADELPHIA, PA.
1888-1915
Washington Denver San Francisco Pittsburgh Los Angeles Seattle Toronto

.03 Railway eng.
7L

UNIVERSITY OF ILLINOIS LIBR
MAY 17 1915

RAILWAY ELECTRICAL ENGINEER

The Official Journal of the Association of Railway Electrical Engineers

Vol. 6 CHICAGO Advertising Bldg., 123 W Madison St. MAY, 1915 $1.00 per year U. S., Canada and Mexico $1.50 per year Foreign No. 12

A Characteristic Benjamin Installation in the New Chicago & Western Indiana Round House

A Good Lighting Installation Spells Years of Satisfaction

The above illustration shows the new roundhouse of the Chicago & Western Indiana Railroad at Chicago. There are four lighting units per stall equally spaced, 2-150 watt units in the center and 2-100 watt units at each end of the stall. Notice the very uniform and abundant illumination. The outside approaches are effectively lighted with Benjamin "Angle reflectors." The shop electrician is enthusiastic about "Benjamin." It would do you good to hear him tell about the results attained.

Good lighting brings efficiency, good will among the men and greater safety into a plant. It is an investment which pays for itself many times over. This fact is now appreciated by railroad officials. Good lighting means a proper installation of efficient reflectors. Why not get the benefit of our recommendations? Our Illuminating Engineers will gladly send you theirs.

Write us for a copy of our Lighting Bulletin

Benjamin Electric Manufacturing Company

120-128 South Sangamon Street, CHICAGO, ILL.

NEW YORK SAN FRANCISCO

Willard STORAGE BATTERY

NO-WASH

How About Your Cars on The Branch Lines?

They are as important as those on the main line—but they don't come into the shops as often for thorough inspection.

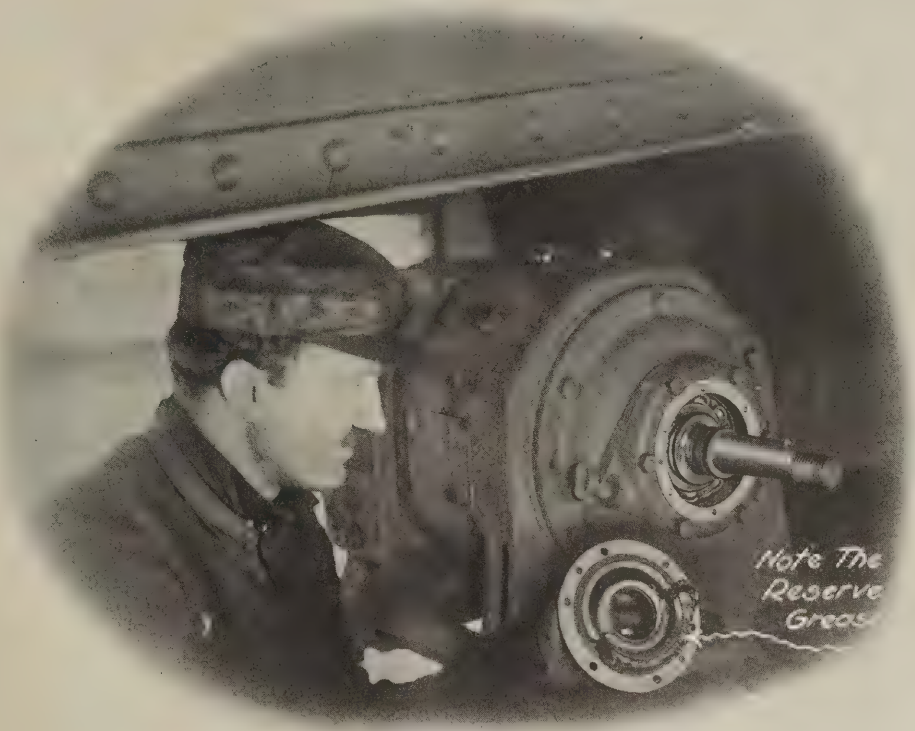
The *average* storage battery must have *constant* attention—washing, cleaning, repairing, overhauling.

But there's the big advantage of the WILLARD NO-WASH. It goes on giving good service during its entire life without having to be removed for cleaning.

Moreover, the fact that WILLARD NO-WASH batteries are made of higher grade materials and with more advanced features of construction increases their life and decreases the cost of maintenance. This is true even where the batteries are not under rigid shop supervision because such attention is unnecessary to assure NO-WASH performance.

Bulletin No. 103 on request.

Willard Storage Battery Company
CLEVELAND, OHIO
New York Chicago San Francisco Detroit Indianapolis



All Winter on One Greasing

and Plenty of Grease Left

This sounds like a remarkable record—but it isn't. It's just what hundreds of Hess-Bright Ball Bearings have done during the past winter.

This machine, on Santa Fe car No. 2972, was inspected and properly greased October, 1914. A tag "No. 4," indicating that on the six months inspection basis the equipment would be due for regreasing in the fourth month of 1915, was attached to the machine. The bearing was not greased, not even opened, for six months. On April 22nd, 1915, the pulley and bearing cap were removed and the bearing was found to be in excellent condition with plenty of reserve grease, as shown by the accompanying photograph.

The saving in maintenance and lubricant and greater reliability of car lighting generators mounted on Hess-Brights make this bearing a very important part of all first-class car lighting equipments—specify Hess-Brights and insure your car lighting generators against bearing failures.

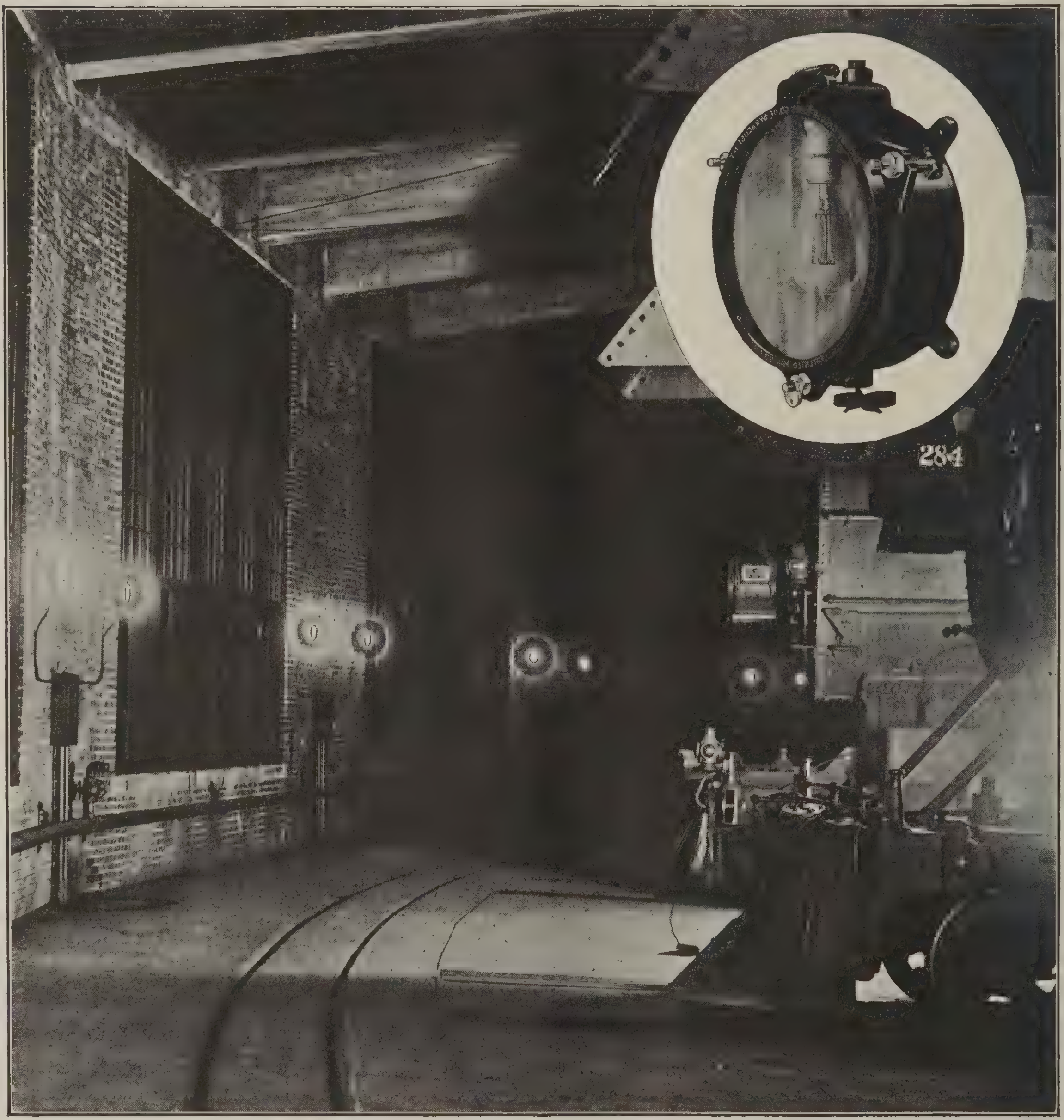
Let us co-operate with you in applying them to new or old equipment.

The Hess-Bright Manufacturing Co.

Front Street and Erie Avenue
PHILADELPHIA, PA.

Right Way To Light Roundhouses
Is With Type RM Reflectors

Give Illumination Where You Need It and Protection From Destructive Gases



Installation of Type RM Reflectors.

Type RM Reflector is Dust-, Gas- and Moisture-Proof. There is one size for 25 to 100-watt, and another for 150-watt standard filament Mazda lamps.

Just the strong Incandescent Lamp Housing and Reflector needed for Roundhouses, Ash Pits, Yards, Passage Ways, etc.

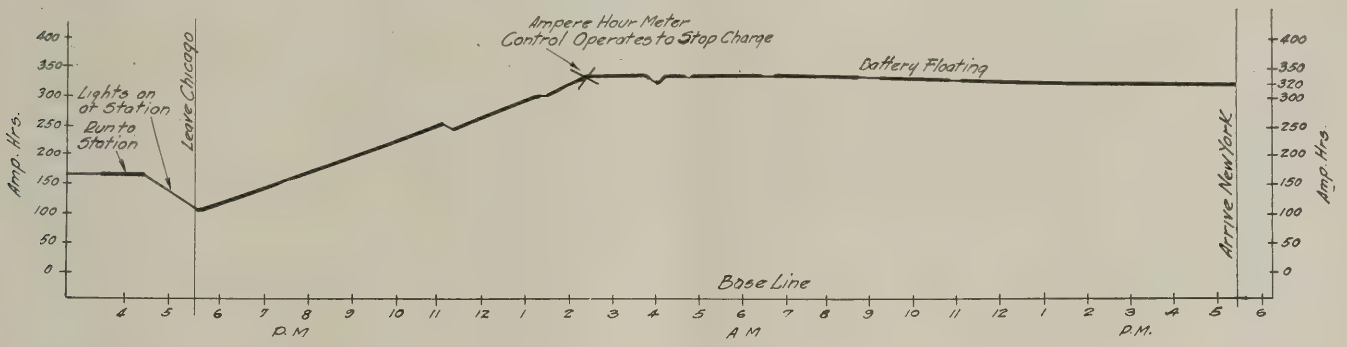
Write for Bulletin No. 300.

Crouse-Hinds Company
Syracuse, N. Y., U. S. A.
NEW YORK BOSTON CINCINNATI CHICAGO

A Graphic Story—

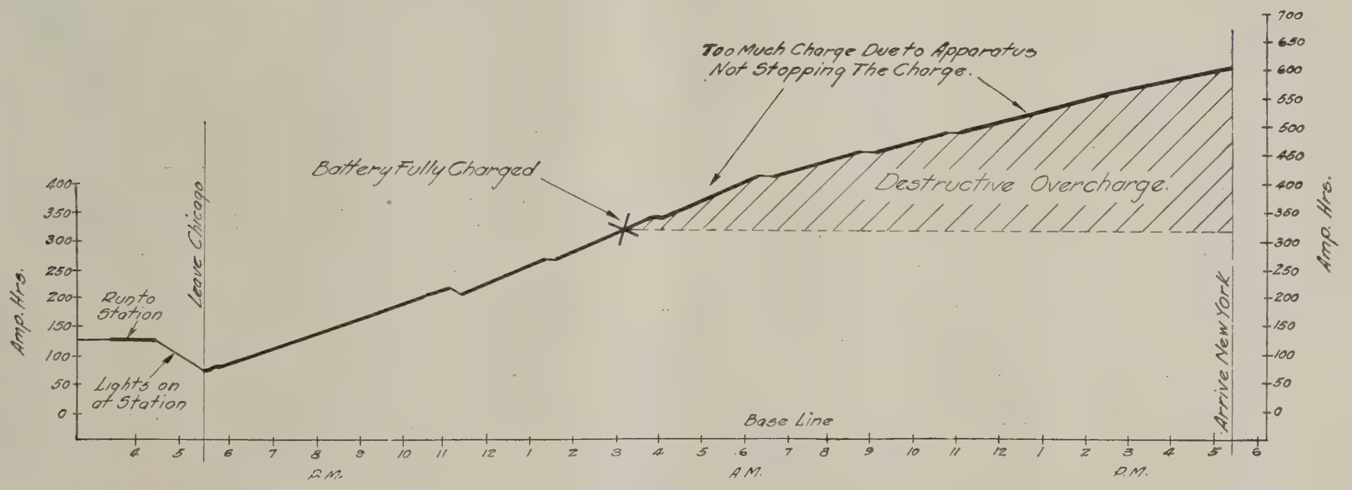
What the Ampere Hour Meter Accomplishes

In the Railway Electrical Engineer for January, 1915, an article appeared describing the graphic ampere hour meter and showing some results obtained in actual service by a prominent car lighting engineer. The two curves given below were taken from this article and graphically illustrate what the ampere hour meter will do for the car lighting battery.



The above curve shows a typical run where the battery charge was controlled on an ampere hour basis. Note that at 2 A. M. the battery became fully charged and the meter automatically stopped further charging. All night and all the next day the battery simply floated on the line, except for a slight discharge at 4 A. M., which was quickly replaced and the battery again floated.

The battery is given the proper amount of charge **measured in ampere hours**; therefore, destructive overcharging is absolutely eliminated.



The second curve tells a far different story; but this is typical of what a great many axle equipments have done in the past. The battery became fully charged at 3 A. M., but the equipment continued to force current through the battery for 14 hours. On this one trip there was an overcharge of approximately 300 ampere hours—think of the effect of such treatment on the storage battery! Is it any wonder that many car lighting batteries have given a life of but 1 to 2 years instead of 8 or 10, as they should?

Any device which produces a taper charge will, of course, reduce this overcharging materially, **provided the voltage is adjusted properly.** If this voltage is two or three volts high, however, instead of tapering to a final current of 5 or 10 amperes, the charge will taper only to about 50 amperes, which is **no taper at all** and conditions as bad as or worse than shown in the second curve, will maintain.

The only way you can reliably control the charge given a car lighting battery, is by means of the ampere hour meter—prove this out for yourself by installing a test graphic ampere hour meter on your own cars for one or two runs and obtain charts showing the actual conditions.

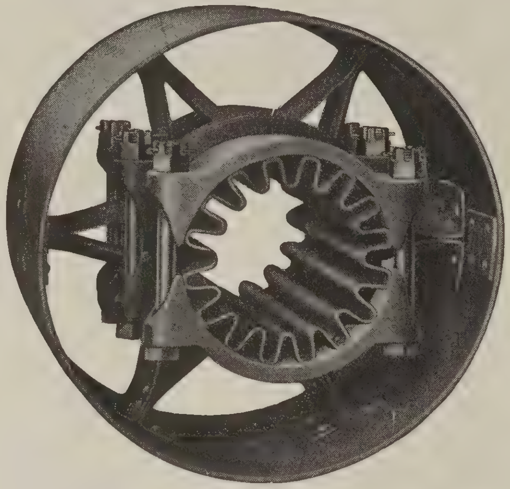
Write us about your requirements.

Sangamo Electric Company
Springfield, Illinois

KEYSTONE
Railroad Axle Pulley

MANY THOUSANDS IN USE

Looks Good, Don't It?

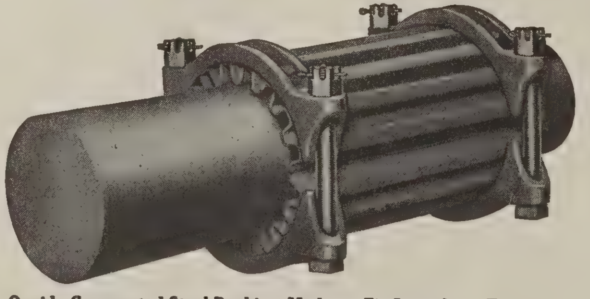


Keystone Railroad Pulley With Oneida Corrugated Bushing
Patented January 8, 1907

The Keystone Pulley with Oneida steel Corrugated Bushing

is the best combination for car axle lighting on the market.

Pulley made flanged or flangeless. Standard 7½-in. bore, 16-in. to 23-in. diameter inclusive. Write for booklet.



Oneida Corrugated Steel Bushing Made to Fit Straight or Taper Axle
Patented January 8, 1907

Oneida Steel Pulley Co.

ONEIDA, N. Y.

The Originators of Steel Railroad Pulleys and Steel Corrugated Bushings

---

If You Are Interested

in prompt shipments, at economical prices, of high grade

Bare Copper Wire
Weatherproof Wire
Rubber Insulated Wire

we solicit your inquiries.

We have large, fresh stocks of these materials and can make immediate shipment of orders, large or small.

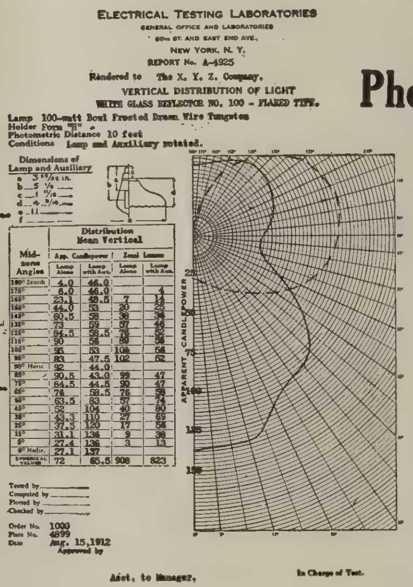
Write to-day to our nearest office for quotations.

Standard Underground Cable Co.
Pittsburgh, Pa.

New York	San Francisco
Boston	Chicago
Philadelphia	St. Louis

For Canada: Standard Underground Cable Co., of Canada, Limited, Hamilton, Ont.

Manufacturers of electric wires and cables of all kinds, all sizes, for all services, also Cable Terminals, Junction Boxes, etc.



ELECTRICAL TESTING LABORATORIES
GENERAL OFFICE AND LABORATORIES
80th ST. AND EAST END AVE.,
NEW YORK, N. Y.
REPORT No. A-4925
Rendered to The X. Y. Z. Company.
VERTICAL DISTRIBUTION OF LIGHT
WHITE GLASS REFLECTOR NO. 100 - FLARED TYPE.

Lamp 100-watt Bowl Frosted Drawn Wire Tungsten
Holder Form "B"
Photometric Distance 10 feet
Conditions Lamp and Auxiliary rotated.

Dimensions of Lamp and Auxiliary
a 3 ¹⁵/₁₆ in.
b 5 ⁷/₈
c 1 ¹¹/₁₆
d 4 ³/₁₆
e 11
f

Mid-zone Angles	Distribution Mean Vertical			
	App. Candlepower		Zonal Lumens	
	Lamp Alone	Lamp with Aux.	Lamp Alone	Lamp with Aux.
180° Zenith	4.0	46.0		
175°	6.0	46.0		4
165°	23.1	48.5	7	14
155°	44.0	53	20	23
145°	60.5	58	36	34
135°	73	59	57	46
125°	84.5	58.5	76	52
115°	90	58	89	58
105°	95	53	104	56
95°	83	47.5	102	52
90° Horiz.	92	44.0		
85°	90.5	43.0	99	47
75°	84.5	44.5	90	47
65°	76	58.5	76	58
55°	63.5	83	57	74
45°	52	104	40	80
35°	43.3	110	27	69
25°	37.5	120	17	58
15°	31.1	136	9	38
5°	27.4	136	3	13
0° Nadir.	27.1	137		
Spherical Values	72	65.5	906	823

Tested by
Computed by
Plotted by
Checked by

Order No. 1000
Plate No. 4899
Date Aug. 15, 1912
Approved by

Asst. to Manager. In Charge of Test.

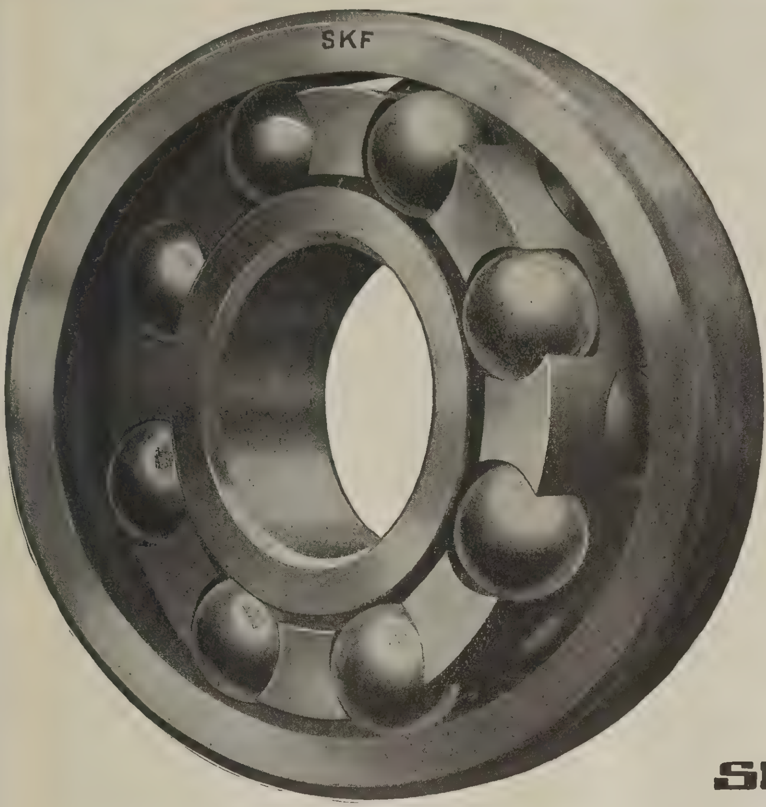
The Photometric Curve

has become necessary for all illuminating engineering computations.

In order to make our services more valuable, a new photometric sheet has recently been designed for use in tests of this character, which presents not only the polar co-ordinate curve, but also the engineering data which makes the sheet complete for all engineering calculations.

Copies of a specimen report will be sent upon application.

Electrical Testing Laboratories
80th Street and East End Avenue
NEW YORK



Put An End to Generator Troubles

If you are equipped with those big, solid ball bearings, you can forget about lighting generator troubles.

Look at these specifications:

Each S. K. F. No. 412 has 16 one-inch balls.

There are two rows of balls in each bearing.

The bearing is self aligning—each row of balls carries its full share of the load.

You get virtually two bearings in one.

Balls and races made of Swedish Steel.

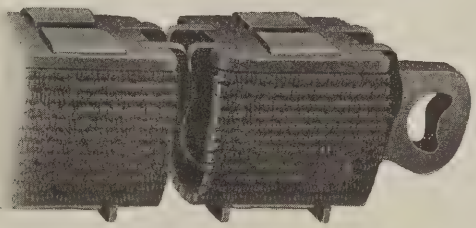
SKF BALL BEARING CO.

Specify S K F Ball Bearings No. 412

50 Church Street New York City

THE V BELT UNAFFECTED

By Atmospheric Conditions



The chain is composed entirely of high grade case-hardened steel, the joints of which are completely enclosed so that they are free from contact with elements of the weather.

The links of the chain are each covered by a strip of chemically prepared canvas belting which is unaffected by ice, snow, sand or ballast.

The belt runs in V grooved pulleys and as the belt at all times covers two-thirds the circumference of these pulleys no ice can work its way into and clog these grooves so that the belt is at all times ready for service.

Owing to its rigid construction it is next to impossible to lose as there must be wear through one-quarter inch case-hardened steel.

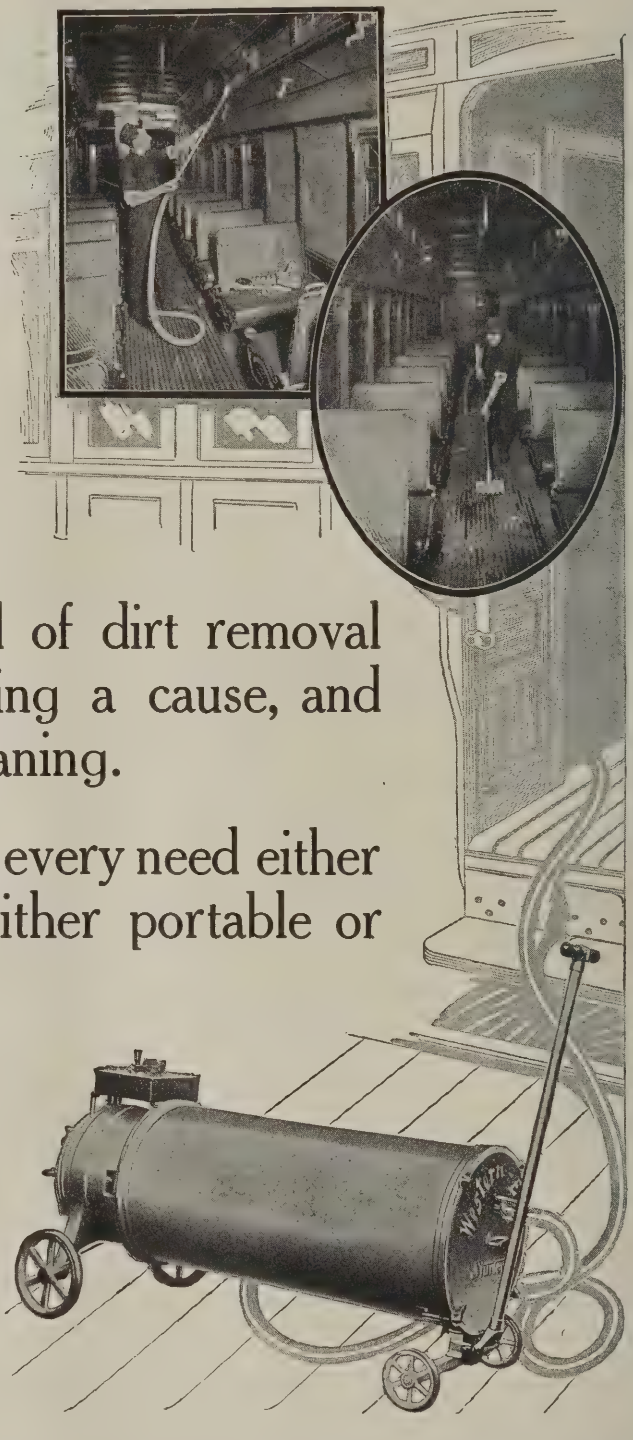
Peerless V Belt Company

Monadnock Block Chicago, Illinois

Clean and Renovate Your Cars at One Operation

Western Electric
Sturtevant
Vacuum Cleaners

furnish a steady suction that pulls the dirt out of cushions, crevices and corners, yet does not injure.



This most efficient method of dirt removal prevents decay by removing a cause, and renovates in its perfect cleaning.

There is a size and style for every need either commercial or domestic, either portable or stationary.

Let our nearest house give you a demonstration and a copy of our book

"The Clean Way to Clean"

"SAVE TIME AND FREIGHT"

DYNAMOS-MOTORS
WESTERN ELECTRIC COMPANY
CABLE-TELEPHONES-SUPPLIES

"TELEPHONE OUR NEAREST HOUSE"

Western Electric Company

Manufacturers of the 8,000,000 "Bell" Telephones

New York
Buffalo
Philadelphia
Boston
Pittsburgh
Cleveland
Atlanta
Richmond
Savannah
New Orleans
Houston
Dallas
Chicago
Milwaukee
Indianapolis
Detroit
Cincinnati
St Louis
Kansas City
Omaha
Oklahoma City
Denver
Minneapolis
St. Paul
San Francisco
Oakland
Los Angeles
Salt Lake City
Seattle
Portland
Montreal
Toronto
Winnipeg
Calgary
Vancouver
Edmonton
London
Paris
Berlin
Antwerp
Milan
Rome
Johannesburg Sidney St. Petersburg Vienna Buenos Ayres Tokyo

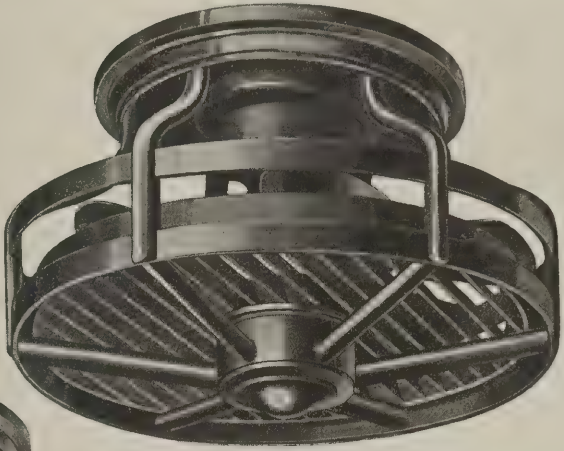
EQUIPMENT FOR EVERY ELECTRICAL NEED

"MEMBER OF"

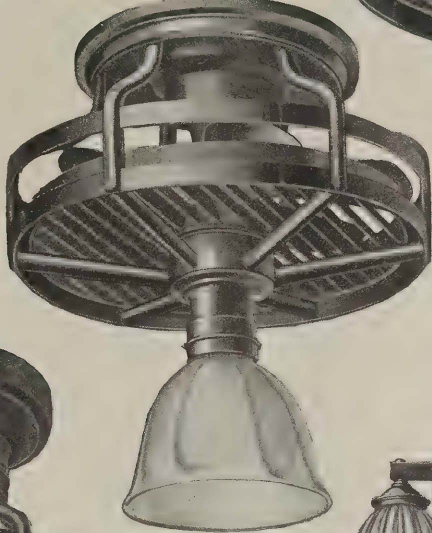
SERVICE
ECONOMY
THE SOCIETY FOR ELECTRICAL DEVELOPMENT INC NEW YORK
EFFICIENCY
SAFETY

"DO-IT ELECTRICALLY"

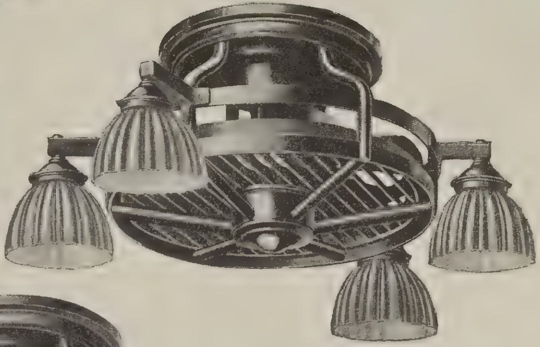
The Safety Electric Fan



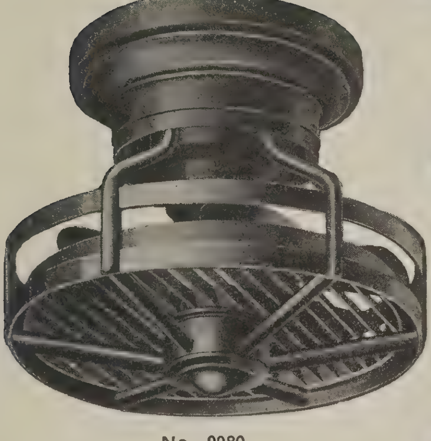
No. 9990
The Fan without Lighting Fixtures



No. 9990-A, 1 Light



No. 9990-C, 4 Lights
Illustrated with No. 9011 Reflectors



No. 9980
Entire Fan, including Motor, located below car ceiling. Can be equipped with one, two or four lights

No. 9990-B, 2 Lights
Illustrated with No. 18630 Reflectors

The success of this type of electric fan is the result of our exhaustive study of railway passenger car requirements. It embodies an entirely new principle in directing air.

Minimum electric current consumption with maximum results.

Redirects air as a reflector redirects light.

Proper and uniform distribution and velocity of air currents on all the useful planes throughout the car.

Not the usual harsh and annoying steady blast of air; but a soft and cooling intermittent breeze every three or four seconds.

Ball-bearings throughout. Three-speed control.

Successfully provides for the combination of a fan and light in one unit.

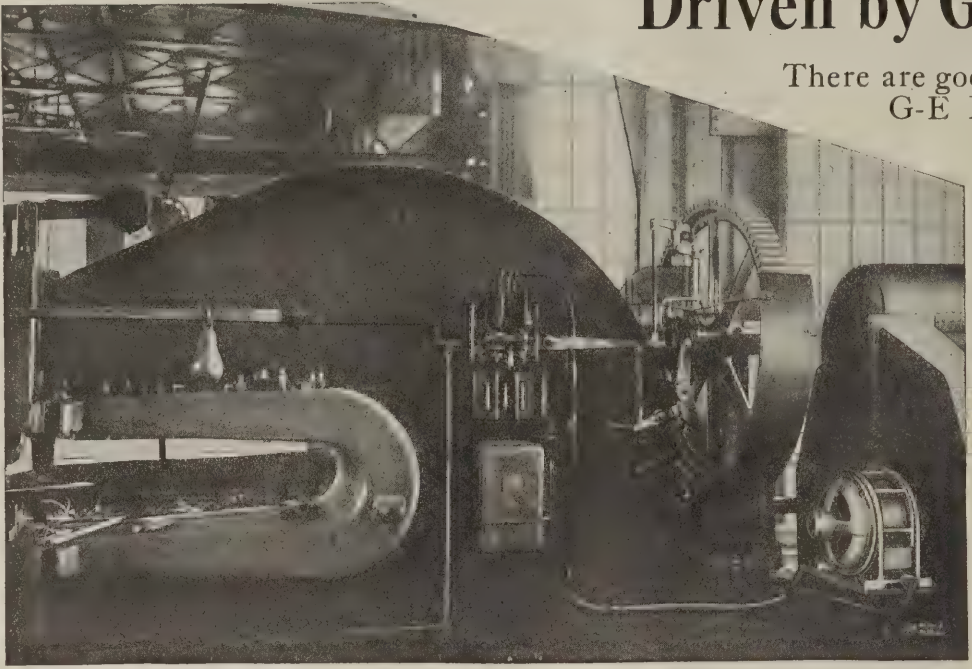
The Safety Car Heating & Lighting Co.

Chicago, Boston,
Montreal
San Francisco

2 Rector Street, New York

Philadelphia
St. Louis
Washington

Shops of Prominent Railroads
Driven by G-E Motors



7½ H. P. Induction Motor Driving Boiler Punch Press, C. C. C. and St. L. R. R. Company, Beech Grove, Ind. , Shops.

There are good sound reasons why G-E Motor Drive is used in the shops of such railroads as the:—

New York Central
Big Four
Great Northern
Florida East Coast
Seaboard Air Line
Boston and Albany
Chicago, Burlington & Quincy
Wabash
Union Pacific
Delaware, Lackawanna & Western
Buffalo, Rochester & Pittsburgh
Norfolk & Western
Oregon, Washington Railway and Navigation Co.
Chesapeake & Ohio
Pennsylvania
Illinois Central
Louisville & Nashville
Georgia Southern & Florida
Boston & Maine
Aurora, Elgin & Chicago
Chicago & Northwestern
New York, New Haven & Hartford
Southern Pacific
Delaware & Hudson
Pittsburgh & Lake Erie
Atchison, Topeka & Santa Fe
Chicago, Rock Island & Pacific, etc.

These reasons include an actual increase in flexibility and output; saving in coal and labor for operating plant as well as greater reliability, safety and efficiency.

The results obtained at one of the shops through the use of Curtis Steam Turbines and G-E Motor Drive are representative:

Coal Saving, 50%
Labor for power plant saved, 66 2-3%
Output increased over 50%

With G-E Motor Drive machines can be arranged entirely independent of power considerations with perfectly clear overhead space for crane operation. They are often mounted on wheels or clamped to an iron floor near the work—machine moved to work instead of work to machine. This electric fan portability is a great convenience and time saver.

Departments as well as machines can be shut down or started up independently and the exact power cost of each is known at all times.

A bulletin describing the equipment of prominent railroad shops will be sent on application.

General Electric Company

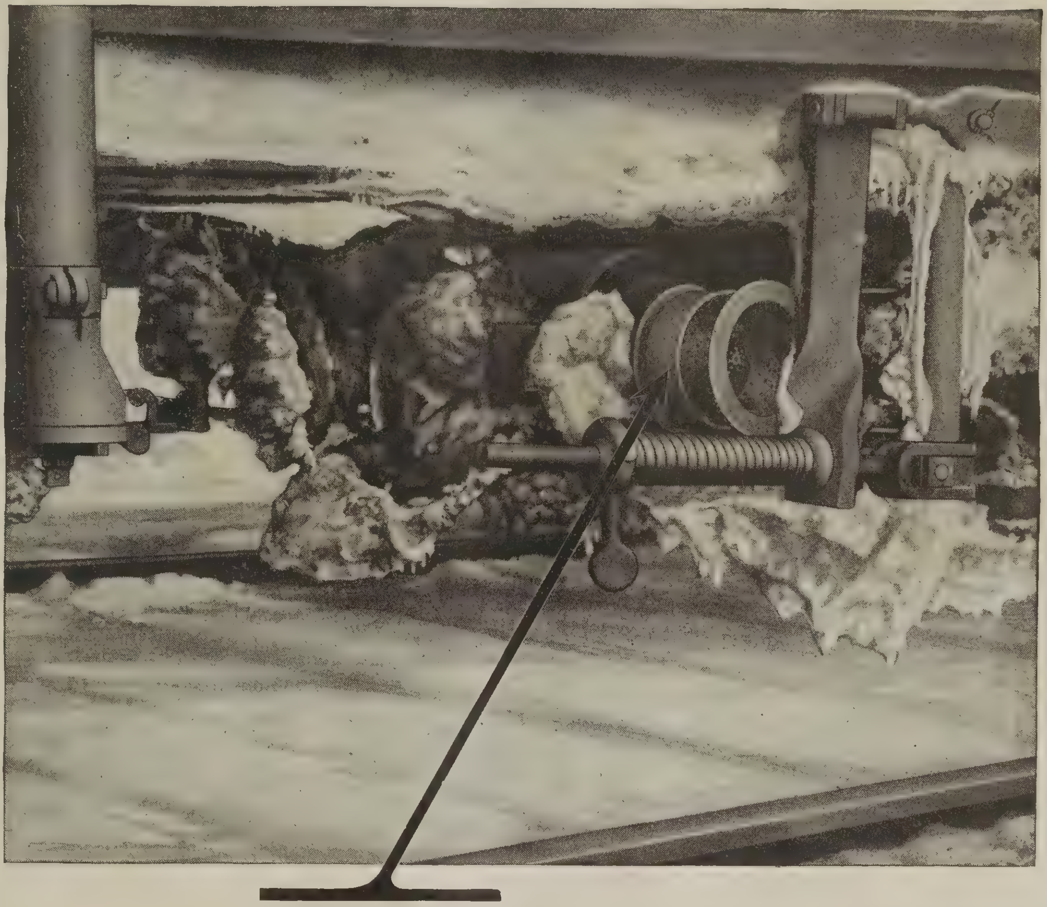
General Office: Schenectady, N.Y.

ADDRESS NEAREST OFFICE

Atlanta, Ga.
Baltimore, Md.
Birmingham, Ala.
Boston, Mass.
Buffalo, N. Y.
Butte, Mont.
Charleston, W. Va.
Charlotte, N. C.
Chattanooga, Tenn.
Chicago, Ill.
Cincinnati, Ohio
Cleveland, Ohio
Columbus, Ohio
Dayton, Ohio
Denver, Colo.
Des Moines, Ia.
Detroit, Mich. (Office of Agent).
Duluth, Minn.
Elmira, N. Y.
Erie, Pa.
Fort Wayne, Ind.
Indianapolis, Ind.
Jacksonville, Fla.
Joplin, Mo.
Kansas City, Mo.
Knoxville, Tenn.
Los Angeles, Cal.
Louisville, Ky.
Memphis, Tenn.
Milwaukee, Wis.
Minneapolis, Minn.
Nashville, Tenn.
New Haven, Conn.
New Orleans, La.
New York, N. Y.
Niagara Falls, N. Y.
Omaha, Neb.
Philadelphia, Pa.
Pittsburg, Pa.
Portland, Ore.
Providence, R. I.
Richmond, Va.
Rochester, N. Y.
St. Louis, Mo.
Salt Lake City, Utah
San Francisco, Cal.
Schenectady, N. Y.
Seattle, Wash.
Spokane, Wash.
Springfield, Mass.
Syracuse, N. Y.
Toledo, Ohio
Washington, D. C.
Youngstown, Ohio

For Texas, Oklahoma and Arizona business refer to Southwest General Electric Company (formerly Hobson Electric Co.), Dallas, El Paso, Houston and Oklahoma City. For Canadian business refer to Canadian General Electric Company, Ltd., Toronto, Ont. 5228

A Fighting Belt



THIS BELT

has stood the *acid test* of *endurance.* Whirled along at 60 miles an hour through blizzards, sleet and zero weather, it has *hung on* with a death grip—and *pulled the load.* *Hundreds* of cars were brilliantly *lighted* all *winter* because a sturdy, *dependable*

GOODRICH
Axle Lighting Belt

kept the generators *going.* This has been the *consistent* record of Goodrich Belts for more than *12 years.* That is why electrical engineers who are *fighting* light failures, *insist* on this belt.

Everything for the electrical engineer

We recommend each of the following to be of the same high standard of excellence as Goodrich Axle Lighting Belt:

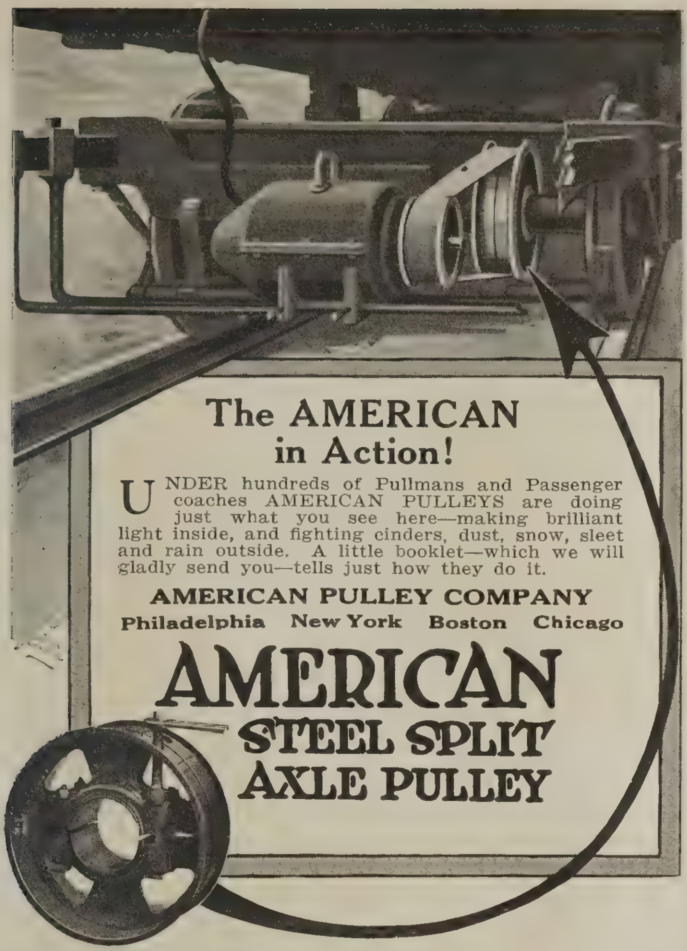
Dynamo Hose
Hand Connector Tubing
Friction Tape
Insulated Wire
Acid-Proof Gloves
Unvulcanized Tape
Lineman's Gloves
Switchboard Mats
Positive and Negative Terminal Bushings

THE B. F. GOODRICH COMPANY - - Factories: Akron, Ohio

GOULD "SIMPLEX" SYSTEM

GOULD COUPLER CO.
GOULD STORAGE BATTERY CO.

New York Chicago San Francisco
Works: Depew, N. Y.



The AMERICAN in Action!

UNDER hundreds of Pullmans and Passenger coaches AMERICAN PULLEYS are doing just what you see here—making brilliant light inside, and fighting cinders, dust, snow, sleet and rain outside. A little booklet—which we will gladly send you—tells just how they do it.

AMERICAN PULLEY COMPANY

Philadelphia New York Boston Chicago

AMERICAN STEEL SPLIT AXLE PULLEY

Do High Voltage Electric Wires Cross Your Right of Way?

Properly protecting these crossings **costs little,** but reduces to a minimum the necessity for costly repairs and the **danger to** not only **property but also human life.**

Our **Overhead Protective Clamping Sets** have been approved or specified by many of the large Railroad, Telephone and Telegraph Companies and important Electrical Committees.

Write us now and let us send you our descriptive bulletins.

Safety Always Pays Big Dividends.

Let Us Send You Some Safety.

The Clark Electric & Mfg. Co.

"Transmission Line Specialists"

Singer Building New York

OLIVER QUALITY E EFFICIENCY

INCREASINGLY SEVERE LEGISLATIVE LAW IS MAKING THE SUBJECT OF ELECTRIC HEADLIGHTS A MATTER OF GRAVE IMPORTANCE TO ALL RAILROADS.

FAILURES COST MONEY

HEADLIGHTS ARE SUBJECTED TO THE MOST SEVERE OPERATING CONDITIONS OF ANY RAILWAY ELECTRICAL DEVICE.

OUR EXPERIENCE IN THIS FIELD HAS MADE US FAMILIAR WITH THESE CONDITIONS AND WE ARE PREPARED TO GIVE YOU THE VERY BEST MATERIAL AND WORKMANSNIP ON REPAIRS AND NEW PARTS.

KEEP COST DOWN BY USING OLIVER

FIELDS—BEARINGS—SHAFTS

BRUSHES—SOLENOIDS—ELECTRODE HOLDERS

ARMATURES & COMMUTATORS

OLIVER ELECTRIC & MFG. CO.

2217-19-21 LUCAS AVE. ST. LOUIS, MO.

KERITE–
TIME–FACTS–
CUMULATIVE EXPERIENCE
roll up the Record
of its
Unequalled Service
DAYS KERITE
KERITE INSULATED WIRE & CABLE COMPANY
NEW YORK
CHICAGO
Lillibridge 60-232

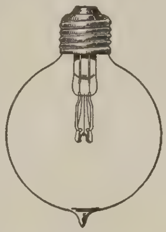
HEADLIGHTS

Over 1300 locomotives are already equipped with MAZDA incandescent electric headlight lamps, of the special concentrated type of filament construction. These lamps give a powerful, steady, easily controlled beam of light—no flicker, no delicate mechanism requiring frequent attention, no cleaning, no trimming. They light up the track far in advance to a wonderful degree of brightness, meeting all reasonable state legislation in this particular.

National Mazda Lamps

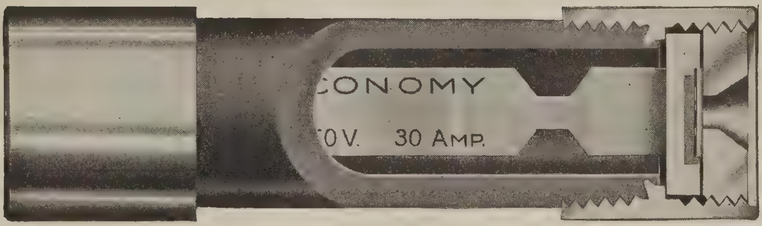
for headlight service include six sizes, according to the following table:

Volts	Nominal Watts	Efficiency, W. P. C.	BulbDia., Inches	Over All Length	Base	St'd Pkg. Quantity	List Price Clear
5½ and 6	36	0.70	2 5/16	3¾	Med. screw	100	$1.25
	72	0.68	3⅛	4¾	Med. screw	50	1.50
	108	0.65	3¾	5⅞	Med. screw	24	1.75
30-34	100	0.80	3⅛	4¾	Med. screw	50	1.50
	150	0.75	3⅛	4¾	Med. screw	50	2.00
	250	0.70	3¾	5½	Med. screw	24	3.00



Our regular scale of discounts apply on the price quotations given above. For more data address

NATIONAL LAMP WORKS
OF GENERAL ELECTRIC CO.
NELA PARK CLEVELAND
Member Society for Electrical Development—"Do It Electrically"



Ferrule Type

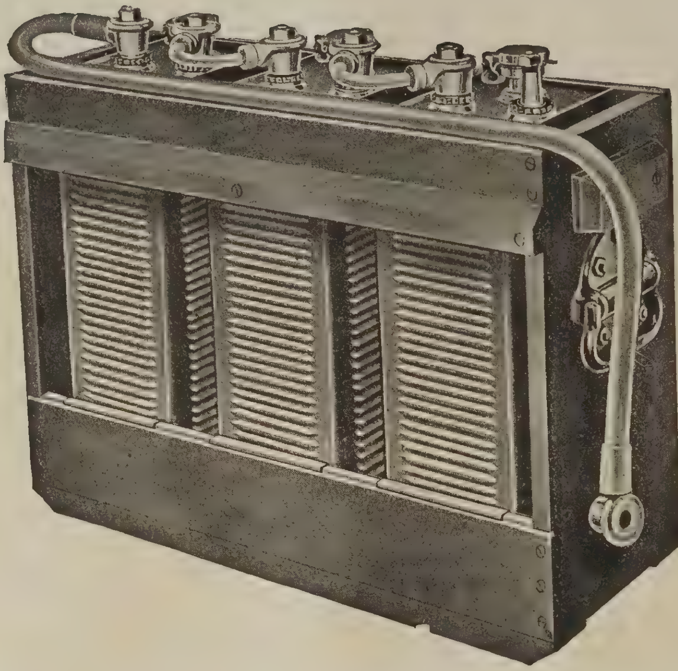
ECONOMY renewable cartridge FUSES

Save 80 per cent annually in fuse maintenance cost, both in the plant and on the cars.

Proof is in Use—Send in Coupon →

ECONOMY FUSE & MFG. CO.
Kinzie and Orleans Streets,
CHICAGO

Economy Fuse & Mfg. Co.,
Kinzie and Orleans Streets, Chicago
Please send Catalog 4, list of users and samples
for............amps ....volts.



The Value of Comparison

The only practical way to find the true worth of an article is to **compare** it with its competitors. No matter what a maker of Storage Batteries may say as to the life, reliability, weight or strength of his battery the buyer **must compare** it to other batteries to get the facts.

The Edison Alkaline Storage Battery

FOR TRAIN LIGHTING

has been consistently marketed on a basis of comparison

We claim, and it is claimed by Railway Car Lighting Engineers who have proved it in practice, that the Edison Standard of Economy and Service is higher than any other. To those who do not yet realize the advantages offered by a steel-encased, non-acid battery we make the following suggestions:

Compare the statements in our Catalogues with those of others.
Compare the different battery records of roads using both Edison and others.
Compare the battery operations of roads buying Edison exclusively and of those buying others.

Have you not put this off too long already?

EDISON STORAGE BATTERY COMPANY

Factory and Main Office: Orange, N. J.

DISTRIBUTORS IN

New York Chicago Boston Cleveland Washington
San Francisco Los Angeles Portland, Ore. Seattle

Alba Lighting Equipment in Lake Shore Diner

From the viewpoint of comfort and pleasure to passengers, we ask your consideration of Alba Globes and Shades.

Alba gives uniform, agreeable illumination—soft, well-directed light—easy to see and read by.

Alba is handsome in daytime and still more beautiful at night.

And, what is most important, Alba is highly efficient—the maximum light for current consumed, consistent with comfort to passengers.

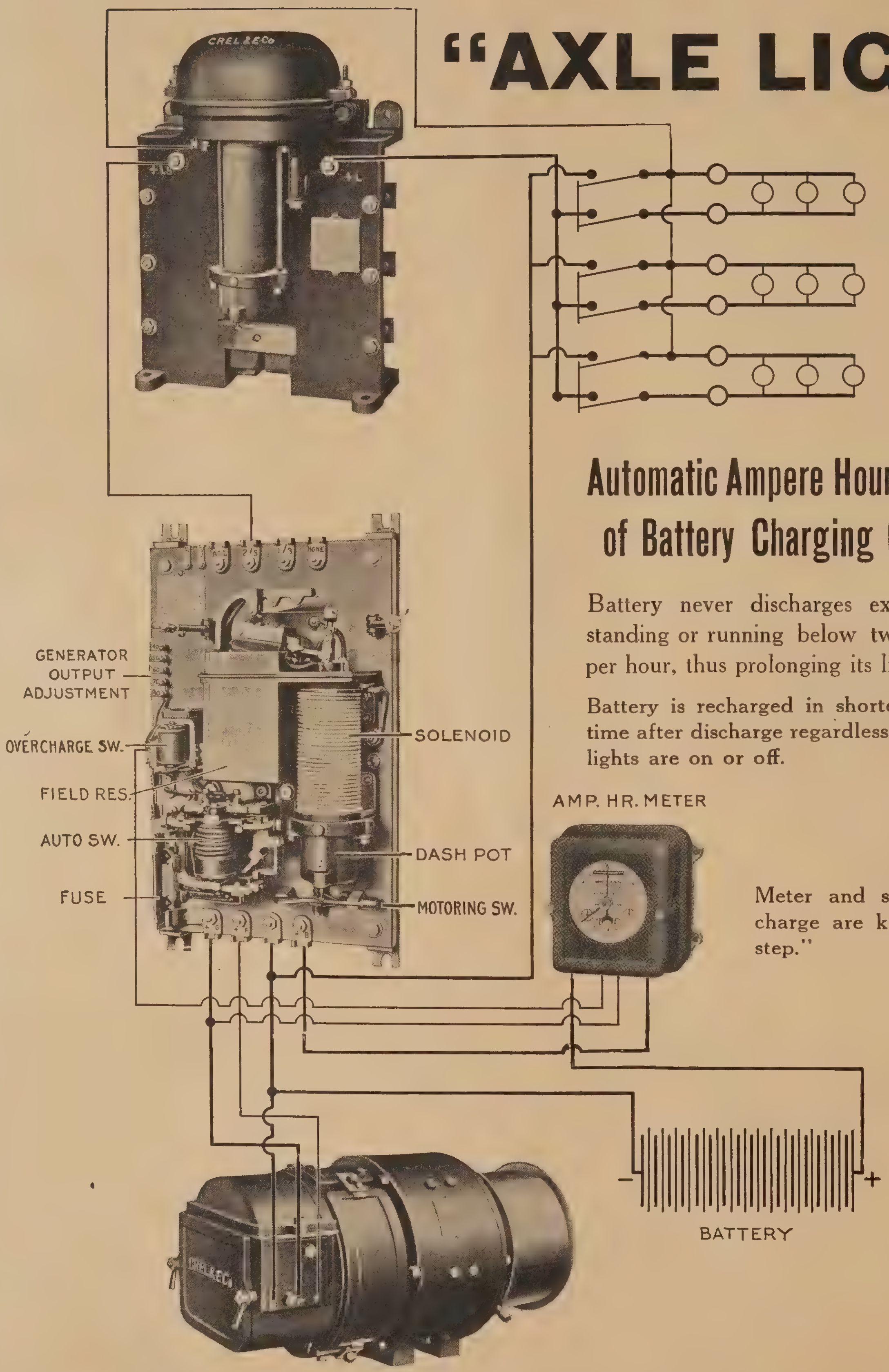
Let us send you Alba Globes and Shades to test out for yourself. Just mail us a diagram of your outlets and we will send the right glassware.

Macbeth-Evans Glass Company
Pittsburgh

Sales and Showrooms also in New York, Chicago, Philadelphia, St. Louis,
Boston, Cincinnati, Cleveland, Dallas, San Francisco.
Macbeth-Evans Glass Co Ltd Toronto

Reg. U. S. Pat. Off.

"AXLE LIGHT"



Automatic Ampere Hour Control of Battery Charging Current

Battery never discharges except when standing or running below twenty miles per hour, thus prolonging its life.

Battery is recharged in shortest possible time after discharge regardless of whether lights are on or off.

Meter and state of charge are kept "in step."

Consolidated Railway Electric Lighting & Equipment Co.

HANOVER BANK BUILDING, NEW YORK
KARPEN BUILDING, CHICAGO